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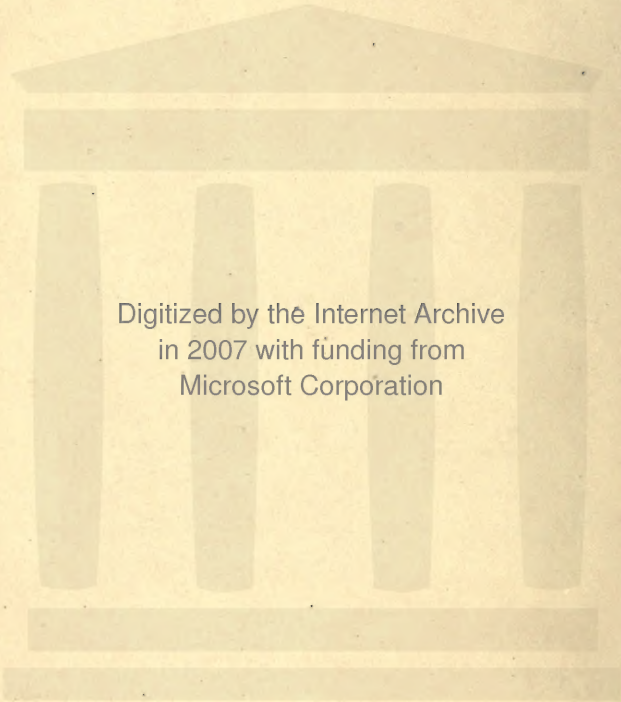

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HANDBOOK

OF

SURGICAL ANATOMY

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DEDICATED TO THE STUDENTS OF THE
MANCHESTER MEDICAL SCHOOL

PREFACE.

Our idea in this small book was to bring together in convenient form, certain anatomical facts, and directly suggest for each a surgical association.

There is of course nothing original in such a book, which is meant to give juniors a selection of some of the more important points in surgical anatomy. As all anatomy is in a sense surgical and medical too, a selection has necessarily to be made. Dental anatomy has received fuller treatment than is usual in books of this size, because in Manchester, medical and dental students receive much of their instruction together, and it is thought that so much dental knowledge as is here presented cannot but be useful to medical practitioners.

Those students, who will read the larger books, will wisely study Treves, and refer to Deaver, and will, we hope, read and read again that best of all books on "applied anatomy," Hilton's Rest and Pain.

We desire to fully acknowledge our indebtedness to various authors, and our own special obligations to H. H. Broome, now of His Majesty's I.M.S., and formerly senior demonstrator of Anatomy at the Owens College, for going through and checking our statements of anatomical facts.

To our Publishers also, we owe our thanks.

If the book is any help to the students of the Manchester School of Medicine it will have done all we want.

G. A. WRIGHT.
C. H. PRESTON.

MANCHESTER, 1903.

PREFACE TO SECOND EDITION.

In issuing a Second Edition we have revised the whole book, corrected some errors kindly pointed out by reviewers and others, and modified certain portions of the text. Room has been made for some few additional facts by omission of paragraphs relating to matters of less practical importance.

G. A. W.
C. H. P.

Surgical Anatomy.

UPPER EXTREMITY.

"Pulp" of the fingers

The subcutaneous tissue over the terminal phalanx of each finger, the "pulp" of the finger so-called, is composed of a tough fibrous meshwork intermixed with fat and supporting the terminal vascular and nervous plexuses.

Whitlow

It is directly continuous with the periosteum of the last phalanx, hence inflammation of the skin or subcutaneous tissue readily extends to the periosteum, and a cutaneous or subcutaneous whitlow may speedily become subperiosteal.

Necrosis of terminal phalanx

The single epiphysis of a phalanx is basal or at the proximal end of the bone, hence in necrosis of a phalanx the shaft often alone dies and is detached, the epiphysis remaining alive. In the terminal phalanx the insertions of the flexor and extensor tendons probably aid in preserving the vitality of the base of the phalanx since even in adults after union of the epiphysis with the shaft the proximal part survives, a line of demarcation forming just below the base of the bone.

The knuckle

The prominence of the knuckle in each joint is formed by the proximal bone, hence in amputating a finger the incision to open the joint is always

to be made just below (on the distal side of) the knuckle.

Joints of the fingers The ligaments of the metacarpo-phalangeal, and inter-phalangeal joints are palmar and lateral, the dorsal ligament is deficient or imperfectly developed and the extensor tendon takes its place. The extensor tendon is also very close to the surface, and the skin of the dorsum is thin, so that a very slight wound may readily not only divide the extensor tendon but also penetrate the joint.

Tendon sheaths The dense fibrous sheaths of the flexor tendons lying on the palmar surface of the first and second phalanges are so tough and unyielding that when inflammatory exudation is poured out within them not only is the patient's suffering great and the constitutional disturbance often severe, but the contained tendon is prone to slough from strangulation.

Thecal abscess The rigid, continuous tube, which runs along the phalanges, is replaced opposite the joints by a thinner and more flexible material strengthened by crucial fibres, hence there is less resistance at these points, and the inflammatory material finding its way there may escape either into the subcutaneous tissue or into the joint.

Incisions to relieve tension and allow exit of matter must be made over the phalanges and not over the joints to relieve strangulation more fully and to avoid opening the articulations which would be at once contaminated if this were done.

Digital vessels and nerves The main arteries and nerves of the fingers course along the lateral aspects of the palmar

surface of each digit, hence an incision for thecal abscess must be made in the middle of the palmar aspect so as to avoid injury to the vessels, and more especially to the nerves, as well as to insure a free opening in the theca.

Joint inflammation

The power of the flexor and extensor muscles of the fingers is so great in proportion to the area of the digital joint surfaces, and the form of the articulations is so simple that it is common, even after suppuration of an inter-phalangeal or meta-carpo-phalangeal joint and destruction of the articular cartilages, as proved by grating within the joint, to find that complete or almost complete mobility of that joint is restored; hence a finger must not be hastily condemned to amputation or permanent stiffness because a joint is disorganised and grating can be felt in it.

Amputation of fingers

The flexor tendons have no insertions into the proximal phalanges and amputation through the first inter-phalangeal joint has therefore been condemned on the ground that power of flexing the stump would be lost. This, however, is not the case, as the tendon readily contracts adhesions to its sheath, and power of flexion therefore is preserved; moreover, the lumbrical and interossei muscles are flexors of the first phalanges.

Synovial sheaths

The synovial sheaths of the flexors of the index, middle and ring fingers extend upwards only as far as the level of the metacarpo-phalangeal joints, and therefore there is comparatively little risk of implication of the great palmar sac from a thecal whitlow of these fingers. It is not, however,

impossible for such mischief to occur, since the inflammation often spreads to the subfascial cellular tissue of the palm, and from this it may spread to the palmar bursa, which is distant only about three-quarters of an inch from the digital sheaths.

The synovial sheath of the little finger is differently arranged, since it is directly continuous with the great palmar sac, and a thecal abscess of the little finger is more likely, therefore, to lead to extensive mischief than is the case with the other fingers. The thumb has either an arrangement like that of the little finger, or has a separate sheath of its own extending from the base of the last phalanx to an inch above the annular ligament of the wrist. The extent of mischief in a thecal abscess of the thumb will, therefore, depend upon which of these anatomical arrangements exists in the particular case.

Skin of the palm and "dermoid cysts"

The skin of the palmar surface of the hand and fingers is devoid of sebaceous glands, hence, under ordinary circumstances, it is impossible to have a sebaceous cyst of the palm. Dermoid cysts, however, are met with, but are not congenital abnormalities, and are in the form described by Mr. Bland-Sutton as "sequestration dermoids," where, after the infliction of a lacerated wound, some portion of the skin is tucked in and enclosed by the healing of adjacent edges over it. The surface of the enclosed skin sheds its epidermis and pours out its secretion of sweat, and a cyst forms containing these materials

and closely resembling a sebaceous or a true dermoid cyst.

Dupuytren's contraction

The skin of the palm is closely tied down to the palmar fascia and to its digital prolongations by vertical bands of fibrous tissue, hence in "Dupuytren's contraction" the skin as well as the palmar fascia, is involved, and requires treatment.

Palmar fascia

The thenar and hypothenar portions of the palmar fascia are sometimes the subject of the same contraction, though, as they are much thinner than the middle portion, the contraction is less marked.

The central portion of the palmar fascia is prolonged into slips for each finger, and these also are often the seat of the above mentioned contraction.

Palmar abscess

As it approaches the roots of the fingers the palmar fascia becomes thinner, and between the fingers is so little resistant that matter lying beneath the fascia in the palm usually works its way down and points between one or other pair of fingers on the dorsal aspect of the web.

The digital arteries and nerves passing towards the fingers lie opposite the intervals between the metacarpal bones, hence an incision through the palmar fascia to allow the escape of pus should be made longitudinally, and opposite the metacarpal bones, not opposite the interspaces. Since the nerves divide earlier in their course than the arteries, and are therefore running more obliquely, they are perhaps, though they lie deeper, more likely to be injured than the arteries, while an incision

at the web of the fingers, if carried too far, would possibly wound a digital artery at its bifurcation.

Ganglia of flexor sheaths

Just at the beginning of the digital portion of the flexor sheath is a weak spot through which a hernial protrusion of the synovial sheath or one of its fringes sometimes occurs, forming a small ganglion.

Superficial palmar arch

Since the superficial palmar arch reaches the level of a line produced across the palm from the palmar surface of the outstretched thumb, an incision crossing this line would probably wound the arch if it penetrated the palmar fascia, while if it went deeper still it would wound the great palmar sac which extends as low as the level of the neck of the metacarpal bones.

The width of the superficial arch is much less than might be supposed, a fact readily recalled by remembering the distance between the radial and ulnar arteries of the wrist, while the deep arch is also the wider.

Deep palmar arch

A deep stab half an inch above the line of the superficial arch would wound the deep arch. A wound dividing deeply the web of the thumb, and either severing the adductor pollicis and the abductor indicis, or penetrating between them, might injure the princeps pollicis or the radialis indicis or its supplementary branch to the superficial arch.

Collateral circulation in palm

The collateral circulation in the palm is exceedingly free, the superficial arch anastomosing externally with the superficialis volæ, the arteria princeps pollicis, or radialis indicis, all branches of the radial, any one of which may complete the arch. By means of the palmar interosseous arteries the super-

ficial arch is brought into connection with the deep arch, which again freely communicates, above, with the anterior carpal arch, and dorsally, by means of the superior and inferior perforating arteries, with the posterior carpal arch and its branches the dorsal interosseous arteries; so that wounds of the palmar arch have always had considerable importance attached to them, and many plans for arrest of the hæmorrhage have been suggested.

Action of extensor tendons

The close relation of the extensor tendon to the posterior aspect of the joints of the fingers has been already alluded to, the tendons by covering over the most prominent portions of the knuckles protect the bones from bruising and also act mechanically at greater advantage from the direction of their line of traction.

Pianist's operation

Accessory tendon slips join the extensor of the ring finger to its neighbours and produce associated action of these fingers. Where this is undesirable, as in playing the piano, division of these bands is sometimes done.

Action of interossei

The interossei, which flex the first phalanx and extend the two last phalanges, preserve some power of extension in the fingers, even if the common extensor is divided on the proximal side of the metacarpo-phalangeal joint.

Fracture of metacarpal bones

It is probably partly by the action of the interossei and of the flexors, as well as by the direction of the violence and the weight of the finger, that the distal fragment in fracture of a metacarpal bone is displaced towards the palm, causing loss of prominence of the corresponding knuckle.

Disease of metacarpal bones

The epiphysis of the metacarpal bone is at the distal end and not as in the phalanges at the proximal end, and it is possible that the close neighbourhood of the epiphysial line to the knuckle, whereby it is exposed to injury, may have some relation to the frequency with which tubercular osteomyelitis is met with in this situation. In its mode of ossification the metacarpal bone of the thumb follows the rule of the phalanges.

Dislocation of thumb

The insertion of the flexor brevis pollicis by two processes, one on each side of the palmar aspect of the base of the first phalanx of the thumb, leaving an interval between them through which the head of the metacarpal bone protrudes in dislocation at the joint, is no doubt in some cases a factor in the difficulty of reduction of this displacement. The presence of the sesamoid bones and the shape of the articular surface, and probably most important of all the infolding of the torn capsule are contributory obstacles. To reduce this dislocation it is therefore necessary first to disengage the bones by hyper-extension and then by flexion towards the ulnar side of the palm (flexion and adduction) as well as direct traction to reduce the displacement.

Nerve supply of fingers

The palmar aspect of the thumb, index, middle and radial half of the ring fingers is supplied by the digital branches of the median nerve, which also give off dorsal branches which are directed backwards, to the supply of the bed of the nail and the skin on the dorsal surface of the second and third phalanges. The ulnar half of the ring finger, and both sides of the little finger, are

supplied in a similar manner by the digital branches of the ulnar nerves.

The dorsal aspect of the thumb, except over the terminal phalanx, which is supplied by the median, and that of the first phalanges of the index and middle fingers, is supplied by the radial nerve, while from the dorsal branch of the ulnar, the nerves to both sides of the little finger, and the ulnar side of the ring fingers are derived. The adjacent sides of the middle and ring fingers are supplied both from the radial and the ulnar nerves. The ulnar nerve sometimes supplies the skin of two and a half fingers on the dorsum of the hand. In wounds of the nerves at the wrist the distribution is often clearly demonstrated.

Nerve supply of muscles of hand

Of the muscles of the palm of the hand the median nerve supplies the opponens, abductor and the superficial head of the flexor brevis pollicis as well as the two outer lumbricales, the ulnar nerve supplies all the rest of the muscles.

Knowledge of the nerve supply of the hand is essential in localising the seat and extent of injury to one of the nerve trunks by a wound as well as useful for many other purposes.

The great palmar bursa

The lower limit of the great palmar bursa is, as already mentioned, on a level with the neck of the metacarpal bones; its upper limit reaches about an inch and a half above the lower crease on the front of the wrist, which marks the upper border of the anterior annular ligament. When the sac is distended with fluid, fluctuation can be felt and swelling seen on alternating pressure above the

wrist and in the palm, and if the sac contains "melon seed" bodies a creaking sensation may also be felt. Should an incision be required to empty the sac the upper one should be made just on the ulnar border of the palmaris longus so as to minimise risk of injury to the median nerve and main arteries. In the palm the incision should be either below the line of the palmar arch or above it, and in that case must not in its deeper part exceed half an inch in length. Division of the annular ligament between the scaphoid and trapezium on the outer side, and the pisiform and unciform on the inner side is not advisable, since it would be likely to seriously weaken the power of the fingers by allowing the superficial and deep flexors of the fingers and the flexor longus pollicis to escape from beneath the ligament.

Bony points of wrist

The prominent projection of bone just to the outer side of the tendon of the palmaris longus as it passes into the palm to join the palmar fascia is formed partly by the tubercle of the scaphoid and partly by the ridge of the trapezium. Just to its outer side is the trapezio-metacarpal joint, which is so often painful when the subject of a sprain or "sprain-fracture," the so-called "stave of the thumb."

The corresponding prominence on the inner side of the front of the wrist is formed by the pisiform bone. Close to its radial side runs the ulnar artery, the nerve lying between the two. The unciform process of the unciform lies lower and deeper than

the pisiform bone. These bony points are of importance surgically in many ways besides those mentioned, thus in injuries about the wrist, in excision of the wrist joint, in cutting the palmar flap in amputation at the wrist, in ligature of the ulnar artery at the wrist, or in suture of a wounded ulnar nerve, the position of these bones must be borne in mind.

The os magnum lies just above the base of the middle metacarpal bone, and if dislocated usually forms a prominent projection at that spot on the dorsal aspect of the hand.

Thecal abscess of thumb

In cases where the synovial sheath of the flexor longus pollicis is throughout distinct from the common palmar bursa an operation may be required to let out matter above the annular ligament. In such case the incision should be made well to the outer side of the radial artery, and a director should be passed inwards beneath the vessel to reach the sheath at its upper part.

Median nerve at wrist

The salient tendon of the palmaris longus is conspicuous in the middle of the front of the wrist. Beneath and to its outer side lies the median nerve, becoming superficial between the flexor sublimis and the flexor carpi radialis, and here it should be sought in cases where an operation is required to suture the ends of the divided nerve.

Ligature of radial artery

Half an inch external to the palmaris longus is seen and felt the flexor carpi radialis, which is the guide in ligature of the radial artery; the vessel lies a short distance external to the tendon. Since the radial artery is usually ligatured not more than

an inch above the tip of the styloid process of the radius, the radial nerve will not be seen in the operation.

Ulnar artery

The tendon of the flexor carpi ulnaris is readily made out running down to the pisiform bone, and close to its radial side is the ulnar artery. As already mentioned, an incision to open the upper part of the palmaris bursa should be made on the ulnar side of the palmaris longus to avoid injury to the median nerve, and the knife must be kept close to the tendon so as not to endanger the ulnar artery. The palmaris longus is not always present, and may be obscured by swelling, but it can usually be felt if not seen, and in any case its position is as nearly as possible in the middle line of the wrist. The use of Hilton's method in any case of difficulty would ensure safety.

Bones of forearm

On the outer side of the radial artery is seen the prominent expanded lower end of the radius, which varies in size in different individuals, and is so large in rickety children. On tracing this downwards, the styloid process can be felt overshadowed by the prominence of the closely adjacent tendons of the extensor ossis metacarpi pollicis, and overlying it the extensor primi internodii pollicis.

The styloid process of the radius is an important landmark in cases of injury about the wrist, since in the normal condition it reaches lower down than the styloid process of the ulna, while in a case of Colles' fracture it will be found to be on a level with, or even a little above, the ulnar styloid process.

Tendons of wrist

Just beneath the extensor tendons last mentioned

winds the radial artery. The two tendons themselves may be traced upwards, crossing the radius obliquely through the lower third of the forearm, and their natural prominence is much increased in cases of effusion into their sheath (tenosynovitis).

By laying a finger over this prominent swelling the characteristic creaking sensation ("silken crepitus") may be felt when the patient flexes and extends the thumb. **Tenosynovitis**

A deep hollow lies between these two tendons and the prominent extensor secondi internodii. In the hollow ("anatomical snuffbox") lie the radial artery, a branch of the radial nerve, a vein, and the tendons of the radial extensors of the wrist.

It is in connection with the sheaths of the radial extensors that "ganglia" are most often met with. Hence the swellings are found just above the base of the second and third metacarpal bones to which the tendons are attached. **Ganglia**

These sheaths reach upwards to the level of the base of the lower end of the radius, that is to the upper limit of the posterior annular ligament. **Synovial sheaths of extensors**

The tendons of the extensor indicis and extensor communis digitorum occupy the next compartment of the annular ligament, and their synovial sheath extends downwards to about the middle of the metacarpus; this sheath is also not uncommonly the subject of development of "ganglia."

The extensor minimi digiti and extensor carpi ulnaris have separate compartments, and the sheath of the latter is not very rarely inflamed and forms a prominence over the head of the ulna (tenosynovitis),

while the synovial sheath of the extensor of the little finger is sometimes continuous with that of the wrist joint. The head of the ulna forms a rounded eminence projecting on the back of the wrist when the forearm is in pronation, while in supination the prominent position is taken by the styloid process and the overlying extensor carpi ulnaris tendon. The importance of being familiar with the position of the bony prominences has already been pointed out and is obvious in questions of injuries about the wrist. It should be remembered that the styloid process of the ulna is often broken in Colles' fracture.

Carpal joints

It is often important to be able to localise exactly the seat of a synovitis, *i.e.*, to distinguish whether the wrist joint itself or one of the carpal joints is affected. It must therefore be borne in mind that the synovial sac of the wrist joint proper lies between the radius and the triangular cartilage above and the first row of the carpus below, while the inferior radio ulnar joint and the joint between the ulna and the fibro cartilage is lined by the "membrana sacciformis."

The joint between the trapezium and the metacarpal bone of the thumb has a separate sac of its own, as has the articulation between the cuneiform and pisiform, while all the other joints between the various carpal bones and between them and the metacarpus are lined by one common sac, hence if tuberculous disease attacks, as it often does, the base of one of the metacarpal bones, and extends upwards, it is apt to give rise to widespread disease

of the common sac, while if the thumb is involved the mischief is at first limited to the trapezio-metacarpal joint.

"Washerwoman's wrist"

The ligaments, anterior and posterior, of the inferior radio-ulnar joint are not very strong, hence forcible strains, such as are caused often in Colles' fracture and in constant over use of the movements of pronation and supination as in wringing clothes, are apt to be followed by subluxation at this joint ("washerwoman's wrist").

Fractures of forearm

The whole of the posterior border of the ulna is readily accessible to the touch, though in the upper part of the arm the bone lies in a furrow between the prominent extensor and flexor muscles, hence fractures of the ulna are readily made out.

Only the lower part of the radius is thus superficial. The pronator quadratus tends to approximate the two bones, and the supinator longus, by its attachment to the styloid process, tends to tilt the upper end of the lower fragment towards the ulna in fractures of the lower part of the radius.

In fracture of the radius below the insertion of the pronator teres into the outer and posterior part of the middle of the shaft it is easy to keep both fragments in position half-way between pronation and supination, while if the fracture is above the insertion of the pronator the upper fragment is supinated by the biceps and supinator brevis, and it is impossible to get sufficient grasp of this upper portion to prevent supination, hence the lower

fragment must be supinated also, or the power of rotation will be largely lost.

Olecranon bursa Over the posterior surface of the olecranon is a bursal sac, which is much exposed to injury; this bursa has somewhat thin, ill-defined walls, and it is very common for inflammation of its lining membrane to give rise to severe and widespread cellulitis of the arm, to necrosis of the ulna, and sometimes to disease of the joint.

Fracture of olecranon The insertion of the triceps is by no means limited to the upper part of the olecranon, but extends far along the posterior border of the ulna and to the aponeurosis covering the extensor muscles. In fracture of the olecranon therefore the amount of displacement of the upper fragment depends upon the degree to which these fibrous expansions are torn, and if the bone is merely cracked across without laceration of the aponeurosis flexion of the arm will not separate the fragments, and the comfort of the patient as well as the prospect of a good result will be much greater.

Excision of elbow In excision of the elbow joint also the aponeurotic attachment of the triceps should be preserved as much as possible so as to retain the power of extension of the limb.

Veins of forearm and elbow The median vein passing up the centre of the flexor aspect of the forearm receives a deep vein at the lower part of the bend of the elbow, and then divides into median basilic and median cephalic veins; these, after receiving the anterior and posterior ulnar and the radial veins respectively, become the basilic and cephalic. It is from either

the median basilic or the median cephalic, according to their size, that blood is usually drawn in venæsection. Since the basilic vein is separated from the underlying brachial artery only by the bicipital fascia a careless operator would be apt to wound the artery, and thus possibly cause an arterio venous aneurism. The internal cutaneous nerve is also liable to injury as it crosses either in front of or behind the vein. If to avoid this danger he chooses the median cephalic vein the surgeon may wound a branch of the musculo-cutaneous nerve and a reflex contraction of the biceps and brachialis anticus may cause "bent elbow." Neither of these dangers is, however, very real.

Ulnar artery

The ulnar artery which passes rather more abruptly towards the ulnar side of the limb, and is somewhat longer than the radial, lies upon the brachialis anticus and flexor profundus digitorum muscles; it is covered by the mass of flexors rising from the internal condyle, and is separated by the deep origin of the pronator teres from contact with the median nerve. To the inner side of the vessel lie the flexor carpi ulnaris and the ulnar nerve, to the outer side the flexor sublimis.

Since in the upper part of its course it lies so deeply that access to it can only be gained by division of the mass of muscles rising from the internal condyle, the ulnar artery is seldom ligatured except in the neighbourhood of the wrist.

The "line" of the ulnar artery in the lower two-thirds of its course is from the internal condyle

of the humerus to a point just to the radial side of the pisiform bone at the wrist.

Its large interosseous branch which supplies the bones, many of the muscles, the associate of the median nerve (comes nervi mediani), and anastomotic branches to the carpal, and therefore to the palmar arches, is of surgical importance both for these reasons and because it will probably require one or two ligatures for itself or its branches in amputations through the forearm.

Elbow joint The ligaments of the elbow joint are anterior, posterior, internal lateral and external lateral; the last-named is largely attached below to the orbicular ligament of the superior radio ulnar joint, and while more or less extensive laceration of these ligaments necessarily occurs in dislocation of the elbow joint, the orbicular ligament is of special interest in those cases of subluxation of the head of the radius in which the bone is drawn downwards out of its grasp.

Subbicipital Subtricipital Bursæ Bursæ exist over the upper part of the bicipital tubercle of the radius, and beneath the lower part of the triceps. Enlargement of the former may cause difficulty in flexion and extension of the elbow as well as in movements of pronation and supination, by its interference with the tendon of the biceps, and in tuberculous disease of the elbow the subtricipital bursa affords an area of lessened resistance along which the disease may spread up the back of the arm.

Bony points of elbow The bony prominences about the elbow are for the most part easily defined, though the tubercle

of the radius obscured by the insertion of the biceps into its posterior part, with the bursa covering the anterior part, is not easily made out, and the coronoid process lies so deeply that even if it is suspected that a fracture of it has occurred it is almost impossible to verify by palpation the exact nature of the injury. The condyles of the humerus and the olecranon are, of course, conspicuous, and, in the dimple below the outer condyle, the head of the radius is readily felt to rotate in alternate pronation and supination. The olecranon lies slightly nearer the internal than the external condyle, and in extreme extension its tip lies in the same line as the two condyles, while in flexion of the forearm to a right angle the three bony points form the angles of an equilateral triangle. In this position of flexion the olecranon is on a plane anterior to the posterior surface of the lower end of the humerus.

All these points are of the utmost importance surgically, and it is only by careful examination of their relations to one another that it is possible to discriminate between some of the various injuries liable to occur in this neighbourhood. The value of Rontgen rays is in some of these cases especially great.

Fractures of elbow

The head of the radius and the upper part of the olecranon are formed as epiphyses, and the lower end of the humerus is built up of four epiphyses, one for each epicondyle and one each for the trochlea and capitellum. Either of the epicondylar epiphyses may be detached separately, or the conjoined epiphyses of the trochlea and capitellum may be

detached, leaving the epicondyles fixed to the diaphysis, or the whole of the epiphyses conjointly may be detached from the diaphysis. This last injury is only likely to occur in early childhood. Finally the trochlear epiphysis with the internal epicondyle or the capitellar epiphysis with the external epicondyle, may be separated from the rest.

Ulnar nerve The position of the ulnar nerve lodged between the olecranon and the internal condyle is important since it is liable to injury in excision of the elbow, while cases of dislocation of the nerve to the front of the internal condyle have been met with.

Musculo-spiral nerve On the outer side the musculo-spiral nerve divides a short distance above the elbow into radial and posterior interosseous, and either the main trunk or the interosseous may be involved in or compressed by callus in fractures of the lower end of the humerus. Temporary or permanent paralysis of the extensor muscles is a result of such compression. A like injury sometimes follows the injudicious use of an Esmarch's bandage or tourniquet.

Lymphatics In the hollow of the bend of the elbow may be found two or three lymphatic glands, the lowest in the arm, which receive lymphatics chiefly from the front of the forearm and the middle of the palm. The rest of the lymphatic vessels of the hand and arm pass up to the epitrochlear gland lying just above the internal condyle or to the axillary glands, or to small glands lying along the basilic vein. Hence, in sores and poisoned wounds of the hand

and arm all of these glands should be examined for evidence of absorption.

Swelling of elbow joint

The prominent internal condyle of the humerus is readily felt even when there is considerable swelling about the elbow, and a line drawn obliquely downwards and outwards, crossing the upper border of the olecranon, will lead to a dimple or depression in which lies the head of the radius. Immediately above this is the external condyle of the humerus. In the radial depression the capsule of the elbow joint is almost subcutaneous, hence in effusion into the joint the swelling speedily obliterates the dimple.

The humerus and its fractures

The sharp supra-condyloid ridges of the lower end of the humerus lead up to the more nearly cylindrical shaft. At the middle of the shaft on the outer side is the insertion of the deltoid, and on the inner side that of the coraco-brachialis, while at this spot the musculo-spiral nerve crosses the back of the bone, and the nutrient foramen perforates the shaft. Since fractures of the shaft commonly occur just above or just below the middle, it is clear that the displacement of the fragments will to some extent depend upon the exact position of the fracture with regard to the insertion of these muscles and of the great pectoral a little higher up on the antero-internal aspect.

A fracture below the deltoid insertion will probably result in a displacement of the upper fragment outwards by that muscle, while if the fracture is higher up, the upper fragment is drawn forwards and inwards, while the lower overlaps it on its outer

side. The displacement, however, depends upon the shape of the broken surface and other conditions besides the effect of muscular action.

A fracture at the middle of the shaft may fail to unite, possibly on account of injury to the nutrient artery, though it is doubtful if this alone would be sufficient to prevent union.

Injury to the musculo-spiral nerve or its implication in callus is less frequent in fractures of the middle of the shaft than in those lower down.

Fractures of surgical and anatomical necks

The epiphysial line of the upper end of the humerus runs through the widest part of the tuberosities, hence a fracture of the surgical neck will be just below and of the anatomical neck above this line. In separation of the upper epiphysis the upper fragment is slightly rotated out and abducted, the lower drawn forwards and inwards by the pectoralis major, but as the surfaces are concavo-convex and broad the ends do not as a rule overlap.

The epiphysial cartilage here, as elsewhere, is more firmly attached to the epiphysis than to the diaphysis, hence, as the line of separation does not run accurately through the epiphysial cartilage, the whole of it, or nearly so, remains usually with the epiphysis.

The epiphysis of the great tuberosity is occasionally detached as the result of disease, or may fail on one or both sides to unite with the shaft.

The shoulder joint

The capsule of the shoulder joint, though strengthened with coraco-humeral and gleno-humeral bands, is so lax that large effusions may

occur within it, and also a wide range of mobility in the joint is possible. Fluid within the joint tends to escape along the prolongation of the synovial capsule which lines the bicipital sheath, or may pass out through the subscapular bursa which communicates with the joint. The subdeltoid or subacromial bursa is occasionally enlarged, but rarely communicates with the joint.

From the attachment of the capsule to the line of the anatomical neck of the humerus reflected fibres pass upwards to the head and convey blood-vessels, so that in unimpacted fracture of the anatomical neck necrosis does not necessarily occur.

The tendon of the biceps acts as a strong anterior ligament to the shoulder joint, so that in rupture or destruction of it there is a projection forwards of the head of the bone, which has been described as a subluxation.

The brachial artery

The brachial artery extends from the lower border of the tendon of the teres major to the middle of the bend of the elbow at the level of the neck of the radius. Its course is from a point at the junction of the anterior and middle thirds of the axilla downwards along the inner side of the arm to its termination. It rests, from above downwards, on the long head of the triceps, on the musculo-spiral nerve and superior profunda artery, the internal head of the triceps, the insertion of the coraco-brachialis, and the brachialis anticus muscles. It is overlapped by the inner edge of the biceps. To its outer side are the median nerve above, the biceps below. To its

inner side lie the ulnar nerve, the internal cutaneous, the lesser internal cutaneous, and in the lower half the median nerves. The basilic vein is also in contact with the inner side of the artery in its upper part after the vein has pierced the deep fascia. The median nerve crosses the artery from above downwards and from without inwards. The vessel is accompanied by two venæ comites, and is covered by skin, superficial and deep fascia. The edge of the biceps is the guide to the vessel. It is better to tie it a little above the middle, since the superior profunda and nutrient vessels usually come off at that level. It may be compressed directly outwards against the humerus. High division of the brachial usually in the upper third of its course is not uncommon, and in such case one or other of the resultant branches may be more superficial in its course than usual.

The axilla The axilla is the pyramidal space between the upper part of the arm and the side of the chest. The base is below, forms the hollow of the armpit, and is closed by the axillary fascia; the apex above communicates with the posterior triangle of the neck by means of the cervico-axillary passage, which is bounded by the clavicle, the first rib, and the upper border of the scapula. The anterior wall is formed by the two pectoral muscles and the costo-coracoid membrane, the posterior by the subscapularis, the latissimus dorsi and the teres major. The internal boundary is the upper three or four ribs and intercostal muscles clothed by the digita-

tions of the serratus magnus; and the external is formed by the upper part of the humerus and the conjoined origins of the short head of the biceps and coraco-brachialis muscles. Through the space run the axillary vessels and nerves, and in it lie glands and loose fat in which suppuration is prone to burrow, and secondary cancerous deposits to grow. The lymphatics drain the trunk walls as low as the umbilicus, and have free communication with those of the neck and interior of the thorax; the lymphatic vessels of the upper limb also pass through the axillary glands. An abscess in the axillary space itself is so pent in by resisting walls of muscle and fascia that its most ready means of exit is sometimes upwards into the posterior triangle. Since no large vessels lie in the middle of the thoracic wall of the space, that is the "seat of election" for opening such an abscess. There are, it must be remembered, many large sebaceous glands in the axilla, and these often become inflamed, causing "superficial axillary abscesses."

The axillary artery

The axillary artery extends from the outer border of the first rib to the lower border of the teres major. With the limb abducted to a right angle the line of the vessel is indicated by a straight line drawn from the centre of the clavicle to the inner side of the slight prominence formed by the coraco-brachialis muscle. The artery is divided into three parts by the pectoralis minor muscle which crosses it. In front of the first part are the pectoralis major and the costo-coracoid membrane, of the second part both pectoral muscles, whilst the third part is

covered in its upper half by the great pectoral, but owing to the anterior axillary fold not reaching as low down as the posterior, its lower half is only separated from the surface by deep fascia, superficial fascia and skin. The divisions of the nerve trunks of the brachial plexus lie above and to the outer side of the first part of the vessel, the three nerve cords of the plexus are arranged around the second part, one behind and two laterally, and the branches derived from those cords surround the third part. Of these branches the ulnar and the lesser internal cutaneous lie to the inner side of the artery, the internal cutaneous and inner head of the median in front, the median and musculo-cutaneous to the outer side, and the musculo-spiral and circumflex behind. The accompanying vein is on the inner side throughout.

Since the artery lies so deeply in the second part of its course it is rarely tied except in the third part, where the incision should be made at the junction of the anterior and middle thirds of the interval between the folds of the axilla. Incisions for any purpose must not be made incautiously on the outer wall of the axilla for fear of the axillary vessels and nerves, nor at the anterior part of the thoracic wall for fear of the long thoracic or external mammary, nor at the posterior part on account of the subscapular, but as a matter of fact there is no danger if the abscess is opened skilfully by Hilton's method.

Axillary lymphatics

The general arrangement of the lymphatic glands is in three sets; the arm set runs along the axillary

vein, the anterior thoracic or mammary set runs with the long thoracic artery beneath the edge of the pectoralis minor and the posterior or dorsal set along the subscapular vessels. These should be remembered in clearing out the axilla in cases of malignant disease. The chain of infected glands can often be traced during an operation high up beneath the clavicle, and little foci of cancerous deposit will be sometimes found studding the lymphatic vessels which run between the axillary glands and the inter-costal spaces with branches of the inter-costal vessels.

Bony points of shoulder

When the shoulder is examined with the arm by the side, the forearm supinated, and the palm of the hand facing forwards, the bicipital groove looks directly forward, a point of importance in examining for injuries and displacements of the tendon or effusion into its sheath. The great tuberosity forms the prominence of the shoulder, which is less salient in fracture of that tuberosity, but wider, while in dislocation the salience is lost. Just above is the acromion, and behind the tip of this is the projection from which measurements of the arm are usually made. Tracing the acromion in the other direction, we soon come to the clavicle and the acromio-clavicular joint bevelled in such fashion that the scapula slips under the clavicle in dislocation of the joint. Just below the clavicle in the depression between it and the upper end of the humerus is felt the coracoid process, an important landmark in excision, amputation and other operations, as well as in injuries about the shoulder. If

the acromion is traced backwards it passes into the spine of the scapula, which is sometimes fractured.

Irregularity in the acromion, or looseness of more or less of its tip, may be the result of fracture or of separation, or of incomplete ossification of the epiphysis.

THE NECK.

Skin The skin of the front of the neck is thin, and its mobility over the deep fascia very great. These points render it very suitable for plastic operations. It is to be noted that the sliding of the skin over deeper structures may cause the inclusion of a small amount of air in the tissues near a wound of this region, though there may be no communication with the respiratory tract.

Platysma The mobility of the skin produced by the platysma myoides renders difficult the healing of sinuses left after abscess in this region.

Branchial fistulæ Congenital fistulæ may be present on the front of the neck due to the imperfect closure of branchial clefts. The second, third and fourth post-oral clefts open, when persistent, along the anterior border of the sterno-mastoid, and in this line the fistulæ due to defective closure are found; those from the second cleft about opposite the angle of the jaw, those from the third at the level of the thyro-hyoid space, and those from the fourth just above the sterno-clavicular joint. The first cleft

forms the Eustachian tube, tympanic cavity and external auditory meatus. Defective fusion of aural tubercles, which normally unite, gives rise to the fistulæ sometimes met with in the helix and between the antitragus and lobule of the pinna. Little tags or folds of skin known as "supernumerary auricles" may be found overhanging these auricular fistulæ or those in the neck.

Supernumerary auricles

The original branchial cleft may persist in any part of its course through the neck, and if both external and pharyngeal orifices are closed a cyst may be formed by distension of the canal.

Cysts

The skin of the back of the neck is closely attached to subjacent parts, and as it is a common site for carbuncle and boils, much pain is caused by the unyielding nature of the tissues.

The *posterior triangle* is bounded in front by the posterior border of the sterno-mastoid, behind by the anterior border of the trapezius, and below by the clavicle between the attachments of these two muscles. It is divided by the posterior belly of the omo-hyoid into the occipital triangle above and the subclavian below.

Surgical areas

Posterior triangle

The *anterior triangle* is bounded in front by the middle line, behind by the anterior border of the sterno-mastoid, and above by the border of the lower jaw, and a line continuing it back to the sterno-mastoid. It is divided into muscular, carotid, and digastric triangles.

Anterior triangle

These areas are covered in by the tough, dense, deep cervical fascia which completely envelopes the neck. It is attached behind to the cervical spines

Cervical fascia

from which two layers pass outwards on each side, enveloping the trapezius and blending along its anterior border. The fascia passes across the posterior triangle and splits along the posterior border of the sterno-mastoid. The layers pass above and beneath that muscle and unite at its anterior border, from which the fascia passes forwards as a single sheet across the middle line to the anterior edge of the opposite sterno-mastoid, thus covering in both anterior triangles. Traced upwards, the fascia is found to be attached to the superior curved line of the occipital bone and the outer surface of the mastoid process. Between the mastoid and the angle of the jaw it blends with the fascia covering the parotid, and so gains attachment to the zygomatic arch. From the angle to the middle line the fascia is attached to the border of the lower jaw. Over the trapezius it blends with the deep fascia of the shoulder and back. Traced forwards, it is attached to the clavicle along its whole length and to the superior border of the manubrium sterni. From this outer coat processes or partitions pass inwards between the structures of the neck.

The chief of these are:—

Carotid sheath 1. The *carotid sheath* formed by two processes from the layer covering the under surface of the sterno-mastoid.

Prævertebral fascia 2. The *prævertebral fascia*, springing from the posterior part of the carotid sheath and stretching across the neck immediately in front of the spine and prævertebral muscles. This layer is attached

above to the base of the skull, and passes down into the thorax behind the gullet.

3. The *prætracheal layer*, given off near the anterior border of the sterno-mastoid, covering the larynx, trachea and thyroid gland, passes behind the depressors of the hyoid bone and enters the thorax on the front of the trachea to blend with the pericardium. Since the cervical fascia is attached to the body of the hyoid bone this last layer reaches no higher than that structure. **Præ-tracheal fascia**

After blending with the posterior layer of the carotid sheath the prævertebral fascia passes outwards, invests the scaleni muscles and joins the costo-coracoid membrane.

Small offsets of less surgical importance are:—

1. A layer passing in front of the sterno-hyoid and sterno-thyroid muscles and attached to the posterior upper border of the manubrium. It shuts off a small compartment containing fat and a lymphatic gland, and as the latter sometimes suppurates, may be efficacious in localising an abscess.

2. Another process is given off near the angle of the jaw between the deep part of the parotid and the submaxillary glands. A thickened portion of this forms the stylo-maxillary ligament.

Beneath the cervical fascia and between the various deeper structures is the loose tissue in which pus may burrow far and wide when once suppuration has occurred. The burrowing of the pus may be guided by the fascia from the neck into the chest, causing pleurisy or inflammation in the mediastina. On the other hand the partitions in **Cellular tissue**

the neck may be broken down and seem to melt away in the abscess cavity, a clean dissection of the muscles and vessels of the neck being thus made, and sometimes erosion of the vessel walls and hæmorrhage occurs. This is occasionally seen in scarlatinal cellulitis. Hence early and efficient drainage is of essential importance to limit the extent of cervical abscess. The resistance of the fascia to the growth of tumours and the spread of inflammation is the great cause of the tension and consequent pain occurring in these conditions.

Subclavian artery, 3rd part

In the subclavian division of the posterior triangle the subclavian artery is usually ligatured. It lies upon the first rib, external to the scalenus anticus, whose tendon is one of the guides to the vessel. The subclavian vein is anterior to the artery and in front of the insertion of the scalenus. The cords of the brachial plexus lie vertically above the artery, the lowest cord in close proximity to the vessel for which it may be mistaken. Superficial to the artery in this region are the nerve to the subclavius muscle in direct relation to the part to be ligatured, the transversalis colli artery which passes across the space about an inch above the clavicle and at a higher level than the subclavian, the supra-scapular artery which leaves the triangle by passing behind that bone and a plexus of veins formed by communications between the supra-scapular and transversalis colli veins. The external jugular vein pierces the cervical fascia over the subclavian triangle about one inch above the clavicle near the posterior border of the sterno-

mastoid, and crosses the subclavian artery to join the vein. It receives a communicating branch from the cephalic vein which crosses the clavicle. The space is crossed superficially by the descending cutaneous branches of the cervical plexus. The phrenic nerve lies upon the anterior surface of the scalenus anticus muscle crossing it obliquely from without inwards behind the sterno-mastoid to reach the cavity of the chest. It is internal to the field of operation in ligature of the third part of the subclavian, but its avoidance would require care in tying the second or first parts. The artery may be tied in its second part, that lying behind the scalenus anticus muscle. Here, as well as in the first part of its course, the vessel is in contact with the pleura below, which is in danger of being wounded.

The subclavian artery is usually said to rise about half to three-quarters of an inch above the level of the clavicle, the pleura reaching to a somewhat higher level. This varies much in different subjects, and a short neck combined with corpulence vastly increases the difficulty of the operation.

Compression

The third part of the subclavian can be compressed against the first rib by pressing deeply in the subclavian triangle downwards, backwards and inwards.

Ligature

When ligaturing the third part of the subclavian the skin of the neck is sometimes drawn down before the incision is made along the clavicle. When the skin retracts the wound is found to be

over the field of operation and the external jugular vein is thus avoided, for it cannot slide down with the skin owing to its piercing the cervical fascia above the clavicle.

The lowest nerve trunk of the brachial plexus is usually visible as soon as the fascia is divided, except in very fat subjects. The artery lies usually just below and the trunk forms a better guide to the vessel than the scalenus anticus muscle, which itself requires finding. The nerve trunk, however, not uncommonly lies behind the third part of the artery. The ligature is passed from above downwards and forwards to avoid the nerve trunks. The vein is in no danger, being separated by half an inch from the artery.

Collateral circulation

The following collateral channels are available after ligature of the third part of the subclavian:—

1. The supra-scapular from the first part anastomoses with the acromio-thoracic and subscapular branches of the axillary.

2. The transversalis colli from the first part by its posterior scapular branch with the subscapular from the axillary.

3. The internal mammary from the first part with the long and superior thoracic branches of the axillary.

4. The thoracic branches of the axillary with the inter-costal arteries of the first two spaces derived from the superior inter-costal branch of the second part of the subclavian.

Operations on glands

In extensive gland disease of the neck it is often necessary to shell out the glands from the posterior

triangle and from beneath the sterno-mastoid and the clavicle. In these operations the structures liable to injury are those mentioned in connection with the subclavian artery; but certain of them—*e.g.*, the phrenic nerve and the subclavian vein, here run greater risk than in the operation of ligature.

Spinal accessory nerve

The nerve of most importance in this region is the spinal accessory which emerges from the posterior border of the sterno-mastoid at the level of the upper border of the thyroid cartilage. The nerve may be stretched or divided here if it is wished merely to influence the trapezius muscle, but it is more usually dealt with at the anterior border of the sterno-mastoid on a level with the angle of the jaw.

Trunks of the brachial plexus

Any of the trunks of the brachial plexus may readily be stretched in the posterior triangle where they lie above the subclavian artery or may be injured by the fragments of a fractured clavicle or pressed upon by aneurysms or other tumours. Various motor and sensory paralyses may thus arise affecting the arm.

External jugular vein

The external jugular vein which pursues a course over the sterno-mastoid from the angle of the jaw towards the centre of the clavicle, and pierces the deep fascia over the subclavian triangle, may be used for venesection when it is desired to relieve the right side of the heart very rapidly. There is a slight risk of air entering the circulation owing to the negative pressure which exists during inspira-

tion in veins near the heart, and their canalisation in perforating the rigid deep fascia.

Superficial nerves Six sensory nerves become superficial at the middle of the posterior border of the sterno-mastoid.

Ascending Of the three derived from the second and third cervical nerves the small occipital passes upwards along the posterior border of the sterno-mastoid to the back of the scalp, the great auricular passes vertically to the back and lower part of the pinna and the side of the scalp, and the superficial cervical passes forwards over the sterno-mastoid at right angles to its fibres to supply the skin of the front of the neck and submaxillary region. Hence injuries to, or growths pressing upon, these nerves may affect the nutrition or sensation of the parts supplied by the peripheral branches.

Descending The three nerves derived from the third and fourth roots radiate downwards to the skin of the chest below the clavicle and over the acromial and upper scapular region. These distributions explain the pain which is sometimes felt in the occiput and chest in cases of caries and tumours of the cervical vertebræ and in growths and inflammatory swellings of the neck.

The pleura The dome of the pleura usually rises one or one and a half inches above the clavicle, enveloping the under and posterior aspects of the first and second parts of the subclavian artery. It lies deeply beneath the sternal and clavicular origins of the sterno-mastoid and the insertion of the scalenus anticus, and does not present in the posterior

triangle. Its risk of injury in the rare operations on the second and first parts of the artery, and in the extirpation of diseased glands has already been noticed. The danger it runs in punctured wounds low down in the neck is obvious.

The sterno-mastoid

The diagonal course of the sterno-mastoid from the mastoid process and occiput to the sternum and clavicle is easily made out. The muscle separates the two triangles of the neck, and has itself important surgical relations. Thus the innominate artery bifurcates opposite the upper end of the right sterno-clavicular joint, which is marked by an interval between the sternal and clavicular attachments of the muscle. It covers the scalenus anticus, the carotid sheath with its contents and the descendens noni nerve. The pleura and first and second parts of the subclavian lie deeply behind its lower end.

The action of these muscles is obviously to bring the back of the head towards the shoulder of the same side, and to rotate the face upwards to the opposite side.

"Wryneck"

The attitude assumed in spasm or permanent shortening of this muscle is called "torticollis" or "Wryneck."

Tenotomy

Division of the sterno-mastoid for wryneck may be done in several ways. Sometimes a puncture is made at the anterior border of the sternal tendon, and this portion is divided about a quarter of an inch above the clavicle between the two layers of the deep cervical fascia enclosing it. The anterior jugular vein passes behind the muscle near its

lower end and runs some risk of being wounded if the section is made too high up or the knife entered too far away from the tendon. If the puncture is made between the sternal and clavicular origins a careless plunge might wound the innominate or carotid artery, while in division of the clavicular attachment the external jugular vein dipping through the fascia close to the posterior border must not be forgotten. The muscle is usually dealt with by open incision.

The spinal accessory nerve The spinal accessory nerve enters the under surface of the sterno-mastoid at a point opposite the angle of the jaw, and may be found by a vertical incision along the anterior margin of the muscle, having its centre at this point. The edge of the muscle must be turned up and the nerve looked for beneath it. It may be readily stretched or divided, and section here paralyses in part both sterno-mastoid and trapezius muscles, though paralysis would not be complete as both muscles receive an additional nerve supply from the cervical plexus, the sterno-mastoid from the second, the trapezius from the third and fourth. The operation is called for in cases of spasmodic torticollis.

Scaleni The scaleni muscles are often involved in the morbid condition of spasmodic torticollis, and hence treatment of the sterno-mastoid and trapezius alone is usually followed by an imperfect cure. The branches from the cervical nerves of the scaleni are not easily accessible. The muscles themselves could be divided near their origin from the ribs through

an incision like that for ligature of the subclavian; but the operation is not commonly practised.

Nerves to posterior muscles of neck

The posterior branches of the cervical nerves which supply the complexus and other deep muscles of the back of the neck have been divided by an incision through the trapezius, since these muscles often share in the condition of morbid spasm. The great occipital and third occipital nerves are found as they issue from the complexus and traced down into its substance till the muscular branches are found.

Subclavian artery

The innominate artery bifurcates behind the upper part of the right sterno-clavicular joint and the first part of the subclavian artery on the right side extends from this point to the inner edge of the scalenus anticus. This course also represents the extra-thoracic portion of the first part of the left subclavian. The vessel on both sides arches outwards over the pleura, which here rises above the clavicle. The artery lies deeply beneath the clavicular origin of the sterno-mastoid. In front of the vessel and beneath the sterno-mastoid are the sterno-hyoid and sterno-thyroid muscles, the internal jugular and the deep portion of the anterior jugular veins, the vertebral vein, the phrenic nerve and the vagus with one or more cardiac branches. Below the vessel is the pleura, and on the right side the recurrent laryngeal nerve. Behind are the pleura and the sympathetic. The recurrent laryngeal nerve passes up behind the right artery and to the inner side of the left. The subclavian vein ending in the innominate is in front of the

artery, but on a lower level. The left thoracic duct crosses in front of the left vessel in its course to the junction of the subclavian and the internal jugular veins.

Thoracic portion of left subclavian

The thoracic portion of the left subclavian reaches from the aortic arch to the left sterno-clavicular joint. It is external and posterior to the left common carotid, and has also the trachea, the œsophagus and the thoracic duct close to its inner side. Behind it is the longus colli muscle, the œsophagus and thoracic duct, and the inferior cervical sympathetic ganglion, and on the left the pleura. In front are the pleura and left lung, the vagus, cardiac and phrenic nerves, the left carotid artery, the left internal jugular and innominate veins, and the sterno-hyoid and sterno-thyroid muscles.

Branches of subclavian

The first part of the subclavian gives off vertebral, thyroid axis and internal mammary branches. The second part gives off the superior intercostal. The share of the transversalis colli and supra-scapular branches of the thyroid axis, and of the internal mammary and superior intercostal vessels in the collateral circulation after ligature of the third part of the subclavian has been already mentioned. If the subclavian be tied above the vertebral the anastomoses between the two vertebrals and the interial carotids at the base of the brain, between the inferior thyroids of opposite sides, between the internal mammary and its two terminal branches, the superior epigastric and the musculo-phrenic with the aortic intercostals and the deep

epigastric, between the superior intercostal and first aortic intercostal, and between the arteria profunda cervicis branch of the superior intercostal and the arteria princeps form collateral channels for supply of blood to the upper limb.

Innominate artery

The innominate artery is best considered here, though it is mainly in the thorax. It lies behind the sternum, extending from the middle of the manubrium to the upper part of the right sterno-clavicular joint. Besides the sternum it has in front of it the sterno-hyoid and sterno-thyroid muscles, the remains of the thymus, the left innominate and right inferior thyroid veins. On its right side are the right innominate vein, the right vagus and the pleura. On its left side is the left carotid. The vessel at its origin lies directly in front of the trachea, but as it passes up it gradually comes to lie on the right side of that structure.

After ligature of the innominate the same collateral channels are open, as after tying the first part of the subclavian together with all the anastomoses between the external and internal carotids of opposite sides, since the right common carotid is continuous with the subclavian on the distal side of the ligature.

Thoracic portion of left carotid

The intra-thoracic portion of the left common carotid has in front the sternum, the sterno-hyoid and sterno-thyroid muscles, the left innominate vein and the remains of the thymus; behind, the trachea, œsophagus and thoracic duct; externally, the left vagus and phrenic, the left subclavian artery and left lung; internally the innominate artery near its

origin; the two vessels are separated higher up by the trachea.

The relations of these large trunks in the chest are more important as interpreting the effects of aneurismal pressure on surrounding structures than from considerations of ligature. They have all been tied, but the occasions justifying such procedure are extremely rare.

The vertebral artery

The *vertebral artery* passes upwards and backwards from a point one-third of an inch internal to the scalenus anticus. It lies on the seventh cervical transverse process in the groove between the scalenus anticus and longus colli and enters the foramen in the sixth vertebra immediately above the point at which it is ligatured. The sympathetic cord is behind the vessel, the vertebral and internal jugular veins in front of it. It is crossed superficially by the inferior thyroid artery and by the thoracic duct on the left side.

Ligature

The vessel has been tied through an incision along the posterior border of the sterno-mastoid. The clavicular origin of the muscle has usually to be partially divided. The artery is accompanied by a sympathetic nerve plexus, and ligature causes contraction of the corresponding pupil.

Inferior thyroid artery

The *inferior thyroid* arises from the thyroid axis at the inner border of the scalenus anticus. It lies at first in front of the vertebral, and then passes inwards behind the carotid sheath. In front of the vessel are the middle cervical ganglion and the thoracic duct on the left side. Behind it is the recurrent laryngeal nerve.

It is usually tied just before it enters the thyroid gland through an incision at the anterior border of the sterno-mastoid, which with the carotid sheath and vessels is displaced outwards.

Carotid sheath

The *carotid sheath* containing the common carotid artery, the internal jugular vein and posteriorly the vagus, lies under cover of the sterno-mastoid, and passes upwards from the sterno-clavicular articulation towards the interval between the angle of the jaw and the mastoid process.

Common carotid artery

This is the line of the common carotid artery, but the vessel ends at the level of the upper border of the thyroid cartilage. The internal jugular vein lies to the outer side of, but somewhat overlapping, the artery, in a separate compartment of the sheath. At the lower part of the neck the right vein moves further outwards, leaving an interval between it and the artery, but on the left side the vein crosses forwards in front of the carotid. In ligaturing the artery the sheath should be opened on the inner side, thus avoiding the vein, and the needle carried carefully from without inwards round the vessel; the vagus, which lies behind and between the two trunks, must, of course, be remembered. The ascending cervical branch of the inferior thyroid artery lies immediately beneath the carotid behind the sheath. The common carotid, as it has no branch except its terminal ones, may be ligatured at any spot sufficiently remote from its extremities, but is usually tied just above or below the point at which the omo-hyoid muscle

crosses it, *i.e.*, opposite the lower border of the cricoid cartilage.

The omo-hyoid muscle crosses the carotid sheath at the level of the cricoid cartilage, while above the omo-hyoid the sheath is crossed by the superior thyroid veins and the sterno-mastoid branch of the superior thyroid artery.

The middle thyroid vein crosses the sheath with the omo-hyoid muscle, and the anterior jugular vein, separated from the sheath by the sterno-hyoid and sterno-thyroid muscles, crosses just above the clavicle.

The lower end of the sheath is covered by the sterno-hyoid and sterno-thyroid muscles.

The artery lies on the cervical vertebræ, the longus colli, the scalenus anticus muscle and the sympathetic nerve. The inferior thyroid artery, and its ascending cervical branch lie behind the sheath. The "descendens noni," really derived from the first and second cervical nerves, overlies the sheath or may run within it.

As the sterno-mastoid overlaps the sheath it must be drawn aside to expose the vessel. Otherwise the artery is superficial, *i.e.*, covered only by skin, platysma and fascia.

The "line" of the artery is from the sterno-clavicular joint to a point midway between the angle of the jaw and the tip of the mastoid process. It lies directly over the prominent transverse process of the sixth cervical vertebra, and can be compressed against this so-called "carotid tubercle"

which is between two and three inches above the clavicle.

Collateral circulation after ligature of the common carotid is carried on by:— **Collateral circulation**

1. The communications between the branches of the two external carotids.

2. The anastomosis at the base of the brain between the vertebrals and internal carotids.

3. The anastomosis of the superior with the inferior thyroid artery of the same side.

4. The junction of the deep cervical from the superior intercostal with the princeps cervicis of the occipital and with branches of the vertebral.

5. The ascending cervical of the inferior thyroid with the ascending pharyngeal and occipital arteries.

Internal carotid

The internal carotid artery continues the course of the common trunk to the base of the skull lying behind and slightly further from the middle line at its origin than the external carotid. It is covered by the skin, fascia and sterno-mastoid, and by them only in the first inch of its course, which is the place of election for ligature. It afterwards passes beneath the parotid gland, the styloid process, the posterior belly of the digastric, the stylo-hyoid, and stylo-pharyngeus muscle; the last two pass between it and the external carotid. The artery is here also crossed by the hypo-glossal and glosso-pharyngeal nerves, and by the pharyngeal branch of the vagus with the occipital and posterior auricular arteries. Posterior to it are the rectus capitis anticus major muscle, the vagus nerve and the superior cervical ganglion of the sympathetic. In-

ternal to it are the pharynx, the tonsil, the superior laryngeal nerve and the ascending pharyngeal artery. The internal jugular vein lies external and posterior to the vessel and at the base of the skull the ninth, tenth, eleventh and twelfth cranial nerves emerge between the artery and vein.

Most of these relations are only of interest as explaining various pressure effects of aneurisms, but the proximity of the internal carotid is to be remembered in the operation of tonsillotomy, though the vessel stands in no real danger. It has been wounded from the mouth by fragments of a tobacco pipe piercing the pharynx in a fall.

The artery is ligatured through an incision at the anterior border of the sterno-mastoid. The internal jugular vein is posterior to it, and the vagus nerve behind and between the two vessels.

External carotid

The *external carotid* artery arising from the bifurcation of the common carotid opposite the upper border of the thyroid cartilage passes upwards to a point midway between the angle of the jaw and the mastoid process. At first it is superficial, overlapped only by the sterno-mastoid muscle, but about one-and-a-quarter inches above its origin it passes beneath the digastric and stylo-hyoid muscles and becomes embedded in the parotid gland in the substance of which it ascends to the neck of the jaw dividing into superficial temporal and internal maxillary arteries.

Below the digastric muscle the vessel is crossed by the hypo-glossal nerve and the facial and lingual veins. Above the digastric the

anterior division of the temporo-maxillary vein crosses the artery. Beneath the vessel at its upper part are the stylo-pharyngeus muscle, glosso-pharyngeal nerve and pharyngeal branch of the vagus.

The external carotid is usually tied opposite the great cornu of the hyoid bone between the superior thyroid and lingual branches. The incision along the anterior border of the sterno-mastoid extends from about the angle of the jaw to the middle of the thyroid cartilage. The sterno-mastoid is drawn backwards, and the artery is then apparent crossed by the hypo-glossal nerve and superior thyroid veins. **Ligature**

Of its branches, which are superior thyroid, lingual, facial, occipital, posterior auricular and ascending pharyngeal, only the superior thyroid and lingual are made the subjects of a formal operation.

The *superior thyroid* rises just above the upper border of the thyroid cartilage, and after giving off a hyoid branch upwards, bends downwards to the upper and outer angle of the thyroid gland. The vessel is usually ligatured at its point of entry into the gland as a step in the operation of removal of a portion of the gland. Two of its branches are of slight surgical importance, viz., the sterno-mastoid branch lying over the carotid sheath and the crico-thyroid, which is liable to be wounded in laryngotomy. **Superior thyroid**

The *lingual artery*, which arises above the superior thyroid, about three-quarters of an inch **Lingual artery**

above the bifurcation of the common carotid, runs at first upwards to the tip of the great cornu of the hyoid bone and then turns downwards, forming a loop which is crossed by the hypo-glossal nerve. It is then continued downwards along the upper border of the hyoid bone, passing under cover of the hyo-glossus muscle until it reaches its anterior margin, where it runs vertically upwards to reach the under surface of the tongue, to the tip of which organ it is continued as the ranine artery.

Ligature Before it reaches the hyo-glossus muscle the lingual artery lies on the middle constrictor of the pharynx and the superior laryngeal nerve, and is crossed by the digastric and stylo-hyoid muscles, the hypo-glossal nerve and the lingual and facial veins. It can be tied in this part of its course by an incision along the anterior border of the sterno-mastoid, but it is in the horizontal part of its course that the vessel is usually ligatured as a preliminary to removal of the tongue. It here lies in the digastric subdivision of the anterior triangle covered by the hyo-glossus muscle and submaxillary gland. The ranine vein lies superficially to the hyo-glossus, as does the hypo-glossal nerve, and rather above the level of the artery. The tip of the great cornu is taken as the landmark for the centre of an incision curved with its concavity upwards and reaching from opposite the angle of the jaw to a short distance below the chin. The posterior belly of the digastric and the submaxillary gland are retracted, and the hyo-glossus divided just above the hyoid bone, when the artery is at once seen.

Facial artery in neck

The *facial artery* arises opposite the angle of the jaw and passes deeply beneath digastric and stylo-hyoid muscles lying in the substance of the sub-maxillary gland. It gives off palatine, tonsillar, glandular and submental branches, and curves round the edge of the jaw at the anterior border of the masseter, where it is readily felt pulsating. It is frequently divided in operations, about the lower jaw and in removing diseased glands.

Occipital artery in neck

The *occipital artery* takes a course in the neck from its origin opposite the angle of the jaw backwards and upwards to the anterior margin of the mastoid process. It passes beneath the digastric and all the muscles attached to the mastoid process. The vessel lies on the internal carotid artery, internal jugular vein, and the spinal accessory and vagus nerves, and is crossed superficially by the hypo-glossal nerve.

The facial and occipital arteries can both be secured near their origin through an incision along the anterior border of the sterno-mastoid. The former is not usually tied in this region. In ligaturing these various branches the parent trunk is first found and then the desired offset identified.

Posterior auricular

The *posterior auricular* artery rises rather above the digastric muscle and ascends through the substance of the parotid to the groove between the pinna and the mastoid process.

The following branches anastomose with their fellows of the opposite side across the middle line of the neck.

1. The Hyoid branch of the Superior Thyroid along the lower border of the hyoid bone.

2. The Superior Thyroid with its fellows and with the Inferior Thyroid.

3. The Crico-thyroid branch of the Superior Thyroid across the crico-thyroid membrane.

4. The Superior Laryngeal branch of the Superior thyroid across the thyro-hyoid membrane.

5. The Hyoid branch of the Lingual along the upper border of the hyoid bone.

These anastomoses often render useless for arrest of hæmorrhage the ligature of the main trunk at a distance from a wound.

A communicating vein from the facial to the anterior jugular will be met with at the anterior border of the sterno-mastoid in the incision for ligature of these various arteries.

Middle Line of the Neck.

Hyoid bone The body of the *hyoid bone* lies in the angle between the lower jaw and the vertical surface of the neck, opposite the fourth cervical vertebra.

Cricoid The lower border of the *cricoid cartilage* is opposite the lower edge of the sixth cervical vertebra in adults.

Trachea The *trachea* is four and a half inches long, and extends downwards from the cricoid, entering the thorax opposite the cartilage between the first and second dorsal vertebræ and bifurcating at the level of the disc between the fourth and fifth dorsal. As

it descends the trachea recedes from the surface. Hence the higher it is in the neck the more superficial is the tube.

Top of sternum

Owing to the obliquity of the upper orifice of the chest the trachea is accessible in front to the level of the disc between the second and third dorsal vertebræ, which indicates the *top of the sternum.* One and a half to two inches of the trachea, comprising seven or eight rings, are above the sternum. A greater length, averaging two and three-quarter inches, is reached by throwing back the head.

Thyroid isthmus

The second, third, and fourth rings are covered by the thyroid isthmus. Besides the superficial structures and the thyroid isthmus the trachea is covered by the sterno-hyoid and sterno-thyroid muscles with their investing fascia and the thyroidea ima branch of the innominate artery, if present, is in front of it. Branches of the inferior thyroid veins cross the trachea at the lower part of the neck, and the left innominate vein crosses just below the orifice of the thorax, while the two anterior jugular veins running down the anterior borders of the sterno-mastoids, closely approach the middle line when they are engorged with blood, and may sometimes both be exposed by one median incision in the operation of tracheotomy.

Tracheotomy

In this operation the first landmark after the division of the integuments is the interval between the sterno-hyoid muscles.

Superior inferior

When they are drawn asunder the trachea is exposed unless the incision has been made over the

thyroid isthmus which may be drawn downwards after division of the fascia above its upper border ("superior tracheotomy") or upwards ("inferior tracheotomy"). It must not be forgotten that too low an incision or too long use of an ill-fitting tube may endanger the left innominate vein or the innominate artery which sometimes lies in front of the trachea as high as the seventh ring. Behind the trachea lies the œsophagus inclining to the left side, and in the groove between the two lie the recurrent laryngeal nerves and inferior thyroid arteries. These structures may be injured if the movable trachea of children be inadvertently drawn to one side when attempting tracheotomy.

Crico-thyroid membrane. Laryngo-tomy

Just between the thyroid and cricoid cartilages is a soft spot that marks the position of the *crico-thyroid* membrane, which is opened in the operation of laryngotomy. The small crico-thyroid arteries are not likely to give trouble even if they are wounded; but they may be avoided by making the opening horizontal and close to the upper border of the cricoid cartilage.

Thyroid cartilage

The prominent anterior border of the thyroid cartilage is obvious in the male adult and always to be made out even in children, though not with such certainty as the cricoid.

Thyrotomy

It marks the junction of the two alæ and is the line in which the cartilage is divided in the operation of thyrotomy.

Thyro-hyoid membrane

Above the notch in the upper border of the thyroid cartilage is the *thyro-hyoid membrane*, which is divided in sub-hyoid pharyngotomy. This mem-

brane is inserted into the upper border of the hyoid, passing behind the body of the bone.

Between the bone and the membrane a bursa is sometimes found which may be distended, forming a cyst in this region. **Sub-hyoid bursa**

The isthmus of the thyroid shows traces of the origin of the gland as an offset from the pharynx in the upward prolongation known as the pyramid and in the so-called levator glandulæ thyroideæ. Higher up traces of the original thyroid duct are seen in the foramen cæcum of the tongue, and occasionally in cysts, which may form at any part of the track between the isthmus and the foramen. These cysts arise from unobliterated portions of the duct, and if part of the lining membrane continues capable of secretion the cyst may gradually enlarge and either form a swelling or, by bursting, a fistulous track may be left in the middle line of the neck. **Thyreo-glossal cyst**

The hyoid bone itself lies a little below the level of the chin when the face looks directly forwards. The interval is increased when the chin is raised, and the hyoid is covered by the jaw when the chin is depressed. In the neck the greater cornua can be traced plainly outwards, and their tips serve as landmarks for the lingual arteries, while on examining the throat from within the mouth they are very plainly felt, and are occasionally mistaken for foreign bodies impacted in the fauces. The finger passed through the mouth can be hooked behind the body of the hyoid, and can pull the bone forwards and with it the tongue. This manœuvre is of use when the tongue slips back over the laryngeal **Hyoid bone**

orifice and impedes the breathing in anæsthesia. It also affords a means of controlling bleeding from the lingual arteries.

Thyroid gland The thyroid gland, unless enlarged, is not distinctly to be made out, but the lobes are applied to the sides of the larynx and trachea from the middle of the thyroid cartilage to the sixth tracheal ring.

"Goitre" In disease, however, they form prominent masses, extending outwards from the middle line on one or both sides, and may reach so far as to displace the carotid sheath to the posterior border of the sterno-mastoid. The gland is so closely connected to the trachea and larynx that it rises and falls with them in the act of deglutition. This point is of value in distinguishing thyroid tumours from others not connected with the windpipe.

Œsophagus The pharynx ends and the gullet begins opposite the sixth cervical vertebra at the lower border of the cricoid cartilage. The tube is narrow at this point, and impaction of foreign bodies may here occur. The gullet is nine or ten inches long, and extends to the eleventh dorsal vertebra, where another constriction occurs at the cardiac orifice. The whole distance from the teeth to cardia is about sixteen inches.

In the neck the gullet lies between the trachea in front and the spine behind inclining to the left side and reaching its maximum deviation from the middle line at the root of the neck. It is in relation with the carotid arteries, especially the left, and with the posterior margins of the lobes of

the thyroid gland. The inferior thyroid arteries and recurrent laryngeal nerves are in the grooves between the gullet and trachea, while the thoracic duct is between the former and the spine.

Œsophagotomy

The left side is chosen for œsophagotomy, since the gullet is partly uncovered by the trachea on that side. The incision is made at the anterior border of the sterno-mastoid, and the contents of the carotid sheath are drawn outwards. The middle thyroid veins are divided and ligatured, and the structures in chief danger are the recurrent laryngeal nerve and inferior thyroid artery.

Diverticula

The occasional presence of diverticula from the œsophagus is to be remembered, since impaction of a bougie in one of them may give a false idea of obstruction of the tube.

Lymphatic glands

The lymphatic glands of the anterior triangle are arranged in three main sets, submaxillary, superficial cervical and deep cervical.

The *submaxillary glands* lie beneath the lower jaw, the anterior or submental close to the middle line, and receive vessels from the face, tongue, floor of the mouth, submaxillary and sublingual salivary glands, and from the parotid lymphatic glands.

Important glands lie embedded in the submaxillary salivary gland and are often involved in cancer of the tongue.

The *sterno-mastoid glands* placed along the posterior edge of the muscle receive afferent vessels from the external ear, skin of the neck, and parotid, mastoid and suboccipital glands; thus indirectly draining the back and sides of the scalp.

A suboccipital gland which is often inflamed in children lies over the great occipital nerve and one or two more on the mastoid process.

The *deep cervical or internal jugular glands* or glandulæ concatenatæ lie beneath the sterno-mastoid along the internal jugular vein, and are subdivided into two sets.

1. The *superior* from the bifurcation of the carotid to the base of the skull receive vessels from the internal maxillary glands, thus draining the temporal, nasal, zygomatic and orbital fossæ, the palate, the pharynx, and the thyroid body. They empty into the

2. *Inferior set* placed along the lower part of the internal jugular which receive also vessels from the lower part of the neck, and from the sterno-mastoid cervical glands. Their afferent vessels form the single jugular lymphatic trunk which opens into the thoracic duct on the left side, and into the right lymphatic duct on the right side Glands also lie on the splenius and levator anguli scapulæ in the posterior triangle.

It will be inferred from these connections that the submaxillary glands are the first to be affected by cancer of the tongue or lower lip, or by carious teeth in the lower jaw; whilst in affections of the scalp, such as eczema or parasitic disease, the glands over the mastoid or occiput are prone to be early enlarged. The extensive connections between different groups explain the rarity with which tuberculous disease or even secondary cancer is found confined to one group of glands. It is to be remem-

bered that a few lymphatics from the upper segment of the breast go direct to the lower deep cervical glands. The supra-sternal gland has been noticed in connection with the cervical fascia.

THE FACE.

Skin of face

The skin of the face is freely movable and very well nourished, so that plastic operations are extremely successful here.

Operations on face

Incisions for all operations should be so planned as, on the one hand, to avoid injury to important structures like the parotid duct or a main branch of the facial nerve, and, on the other hand, to render the scar as inconspicuous as possible by making it follow the natural lines of the face or otherwise concealing it.

The various facial muscles are inserted into the skin, and if an incision travels across the direction of their fibres the sutures should be fairly abundant, otherwise apposition of the edges will be disturbed by muscular contraction.

Alveolar abscess

An abscess connected with either jaw should always by preference be opened from within the mouth, or in the case of the inferior maxilla, below the margin of the bone.

Parotid abscess

Similarly an abscess in the parotid should be opened either by an incision parallel with the branches of the facial nerve, or by two or more punctures, rather than by one long incision, and so in other cases.

Facial artery

The facial artery, after crossing the jaw in front

of the masseter, follows a tortuous course to the corner of the mouth, and thence up the side of the nose, lying between the nose and cheek, where it will be wounded in Fergusson's incision for removal of the upper jaw. The vessel terminates at the angular artery, which anastomoses with the nasal branch of the ophthalmic.

The vessel passes beneath the risorius and zygomaticus major muscles, and lies on the buccinator, levator anguli oris and levator labii superioris. The coronary branches run immediately beneath the mucous membrane of the lips, and will be divided in operations for epithelioma and hare-lip.

Branches The chief branches in the face are:—

Inferior labial passing to the chin and anastomosing with the inferior coronary, the submental artery and the mental branch of the inferior dental.

Inferior and *superior coronary* anastomosing with their fellows of the opposite side.

Masseteric anastomosing with the transverse facial branch of the temporal artery.

Lateralis nasi anastomosing with its fellow and with the infra orbital artery.

The frontal branch of the ophthalmic appears at the upper and inner angle of the orbit. The flap taken from the forehead to form an artificial nose is nourished by this last small twig. Remembering the anastomosis between the angular and the nasal arteries, it will be inferred that divided vessels must be secured at the wound itself. Proximal ligature of one or even both facial trunks will be

useless, and both ends of a divided branch must usually be secured.

The *facial vein* has a straight course lying outside the artery. It joins the anterior division of the temporo-maxillary to form the common facial which enters the internal jugular. By the deep facial vein it communicates with the pterygoid plexus, and thence by small veins passing through the foramen ovale, with the cavernous sinus, and by the connection between the angular and the ophthalmic veins another communication with that sinus is established. Septic thrombosis of the facial vein, which may occur in the course of erysipelas or facial carbuncle may thus have most serious consequences. **Facial vein**

The *fifth nerve* becomes superficial upon the face in seven situations; but only three of the twigs are dealt with surgically. **Fifth nerve**

The *supra-orbital nerve* passes forward through a notch or foramen at the junction of the inner third and outer two-thirds of the supra-orbital ridge.

The *infra-orbital nerve* passes out of the foramen in the superior maxillary bone, three-quarters of an inch below the inferior margin of the orbit.

The *mental nerve* passes through the mental foramen half-way between the edge of the alveolus and the lower margin of the jaw.

Trigeminal neuralgia. All these points of exit are in a line passing through the supra-orbital notch and the interval between the bicuspid teeth of either jaw. These branches are sometimes stretched or otherwise dealt with in trigeminal neuralgia. The two last can be readily reached from the mouth by **Trigeminal neuralgia**

incisions in the angle between the lips and the gums.

Distribution The fifth nerve is that of common sensation for the whole of the face as low as the margin of the lower jaw, for the front and sides of the scalp, the teeth, the anterior two-thirds of the tongue and the lining of the mouth, the lining of the nasal cavities, the eyes, the upper portion of the anterior surface of the pinna and the auditory canal by the auriculo-temporal nerve, the parotid gland, and part of the dura mater in the middle fossa of the skull and the tentorium cerebelli. It supplies motor fibres to the muscles of mastication.

Communications It has direct communication with the facial, and, through its ganglia, with other cranial nerves and with the sympathetic.

Referred pain Its sensory origin in the medulla oblongata is in close relation to the origin of the vagus, and so impressions brought from the area of the fifth may be referred to the distribution of the pneumogastric. Also impressions conveyed from the periphery of one division of the fifth may be referred by the brain to the area supplied by other branches. On these principles are explained the frontal headache accompanying ozæna, the frontal pain, the infra-orbital, mental or ear pain or the lockjaw sometimes caused by a carious tooth; the ear and temporal pain and the salivation accompanying ulcers and painful growths of the tongue; also the

Reflex cough and vomiting reflex cough caused by irritation of the fifth nerve in dentition or the vomiting caused by foreign bodies in the auditory canal. The last two

phenomena are caused by the spreading of sensory impressions from the fifth centre to that of the vagus in the medulla, though it is possible that Arnold's nerve might supply the explanation of the last instance. The brain then refers the disturbance in the vagus centre to the distribution of that nerve in the larynx and stomach. "Reflex" trophic changes occur also as a result of lesions of these nerves, *e.g.*, Hilton records change in colour of the hair of the temple (auriculo-temporal) from a carious tooth; the subjects of migraine begin often with a fit of yawning, then get hemicrania, then vomiting, and may have unilateral greyness of hair, which may be more or less temporary.

Direct trophic change, such as inflammation of the eye, followed by sloughing, which often follows operations for removal of the Gasserian ganglion, and makes the operation only justifiable after all other means have failed, must also be remembered, though usually these occur only when the eye is left exposed to irritation after loss of sensation.

The popular remedy of laudanum on cotton wool applied in the ear for toothache and other painful conditions of the third division of the fifth nerve is not only an illustration of referred pain, but also of the efficacy of sedative applications to the area where the pain is felt, the disease being far distant.

Parotid gland

The parotid gland lies in front of the ear and extends deeply into the space between the neck of the lower jaw and the external auditory meatus. It is bounded above by the zygoma, posteriorly by the external auditory meatus, the mastoid process,

and the sterno-mastoid muscle, and below, by a line drawn backwards from the angle of the lower jaw to the sterno-mastoid muscle. In front it extends forwards over the masseter.

Parotid fascia

The gland is encased in a sheath of fascia continuous superficially with the masseteric and cervical fascia, and attached above to the zygomatic arch. A portion of the fascia covering the deeper surface of the gland is thickened, and forms the stylo-maxillary ligament. Between the styloid process and the external pterygoid muscle this deep layer of fascia is interrupted, and through the interval parotid abscesses may point in the pharynx. The unyielding character of the bony and fascial boundaries of the gland explains the excessive pain felt in parotid inflammation. As movements of the jaw cause variation in the tension of the parotid fascia, the pain and difficulty in mastication in "mumps" is readily explicable.

Stenson's duct

Stenson's duct runs over the masseter in a line from the lower border of the external auditory meatus to a point midway between the ala of the nose and the angle of the mouth. It turns sharply inwards at the anterior border of the masseter, and opens on a papilla opposite the second molar tooth. On the face it lies between the transverse facial artery above and the main branch of the facial nerve below. The socia parotidis or supernumerary parotid gland is close to the upper border of the duct. Wound of the duct or even of the socia parotidis may result in troublesome salivary fistula. Some difficulty may be experienced in passing a probe into the duct

from the mouth if the sharp bend near the orifice be not remembered.

External carotid artery

The external carotid artery runs behind the ramus of the jaw as high as the junction of the lower and middle thirds of the posterior border. It then enters the parotid gland and passes upwards in its substance.

Facial nerve

The facial nerve enters the back of the parotid on a level just above the tip of the lobule of the ear. It breaks up into branches which issue from the anterior border of the gland along the whole distance from the zygoma to the border of the jaw. If a vertical incision must be made into the gland, the most important branches will be avoided by keeping below the lobe of the ear. Complete removal of the parotid gland, though quite possible, would be at the expense of permanent facial paralysis, and would involve division of the external carotid, and perhaps of other important vessels and nerves.

Swelling of the parotid from any cause often produces temporary facial paralysis by pressure on the branches of the nerve.

Cartilage in parotid

The parotid may contain persistent fragments of Meckel's cartilage, and these have been supposed to furnish the cartilaginous elements so often found in parotid tumours (Jacobson).

Pre-parotid glands

Over or in the substance of the parotid lie one or more lymphatic glands which receive vessels from the lower eyelid, cheek, side of nose, upper lip, and some of the upper teeth. They are often enlarged from inflammation in any of these localities, and occasionally from secondary malignant growths.

Muscles of expression All the muscles of expression are supplied by the facial nerve.

Peripheral paralysis Lesions affecting the trunk of the facial usually paralyse all these muscles (" peripheral paralysis "), but lesions of the origin of the nerve in the pons usually leave the orbicularis palpebrarum and frontalis muscles unaffected. It is believed that these two muscles are supplied by fibres from the third nucleus of the same side which run in the posterior longitudinal bundle, and join the facial fibres at the genu in the pons, where they bend round the nucleus of the sixth nerve (Mendel). Thus only lesions which take the facial below this point are able to paralyse these fibres.

Central Paralysis

Superior maxilla Tumours The body of the superior maxilla is a shell whose walls are so thin that the bone is readily burst or " expanded " by tumours growing within it. Thus the eyeball may be protruded by forcing up of the orbital floor. The anterior wall of the antrum may be pushed forwards, causing swelling of the cheek. The nasal cavity may be obstructed, or the hard palate depressed by bulging of the inner wall or floor of the antrum respectively.

Tapping the antrum The antrum may readily be opened, either through the sockets of any of the grinders or by perforating its anterior wall through the canine fossa by means of an incision in the angle between the gum and the cheek; or again by opening the inner wall through the nose. The canine socket, though deep, is not suitable for approaching the antrum since it is formed mainly at the expense of

the outer wall, and the fang does not present in the cavity.

Operation on second division of fifth nerve

To reach the second division of the fifth nerve the antrum is opened by gouging or trephining the anterior wall after turning up a flap from the cheek. The infra-orbital nerve can then be followed along the floor of the orbit by chipping away the bone.

Spheno-maxillary fossa

If the posterior wall of the antrum be then trephined just below the nerve, the spheno-maxillary fossa is opened and its contents made accessible.

Meckels' ganglion

The second division of the fifth nerve and Meckel's ganglion, with its palatine branches, are all thus exposed. It is in this manner that extirpation of these structures is carried out in cases of inveterate neuralgia.

Alveolar abscess

An alveolar abscess connected with the upper teeth may point between the cheek and the jaw, or on the surface of the hard palate, stripping up the muco-periosteum, or if the carious tooth is a molar or bicuspid, the abscess may open within the antrum, since the fangs of any of the teeth, other than the incisors or canines, may project through the alveolar process into the antrum. The pus in such cases lies between the bone and the muco-periosteal lining of the cavity, and does not necessarily, or as a rule, cause true empyema of the antrum. It may, however, do so either by perforating the muco-periosteum or by extension of inflammation. Abscess at the root of an upper incisor sometimes points within the nasal cavity.

Pterygoid fossa

Behind the upper jaw is the pterygoid fossa

containing the pterygoid muscles, the internal maxillary artery and its various branches, the pterygoid plexus of veins, and the third division of the fifth nerve with the upper parts of its main branches. This region is covered externally by the ramus of the jaw, the zygomatic arch, the masseter muscle and the insertion of the temporal. Through the fossa is one of the routes by which the third division of the fifth nerve or the Gasserian ganglion are approached in operations for trigeminal neuralgia. The pterygoid fossa is, of course, opened, and various branches of the internal maxillary wounded in excision of the upper jaw.

Alveolar abscess of Lower jaw

An alveolar abscess of the lower jaw usually points between the cheek and the jaw or on the surface of the cheek. It very rarely points inside the jaw, since the inner wall of the alveolus is stronger than the outer one, but it may burrow far down the neck.

Fractures

If the teeth are present, all complete fractures of the body of the lower jaw are necessarily compound, communicating with the mouth. The bone is weakest at the site of the mental foramen, which nearly corresponds with the long socket of the canine tooth. Fracture is commonest here. If displacement occurs the median fragment is drawn downwards by the genio-hyoid, genio-hyoglossi and digastric muscles and the posterior part upwards by the masseter, temporal and internal pterygoid. A canine or incisor tooth is not rarely impacted between the fractured surfaces, and may be a cause of non-union.

Compression of facial artery

The facial artery is most conveniently compressed as it passes over the edge of the jaw at the anterior border of the masseter.

Excision of Lower jaw

In excision of the lower jaw the chief structures liable to injury are the facial nerve, if the incision be carried up the ramus above the lobule of the ear; the external carotid artery and auriculo-temporal nerve in the groove between the neck of the jaw and the external auditory meatus; the internal maxillary artery winding round the back of the neck of the jaw and the lingual nerve.

The periosteum of the inferior maxilla, unlike that of the upper jaw, is fairly efficient in bone reproduction after loss of substance by necrosis.

Subluxation

The inter-articular fibro-cartilage is somewhat liable to spontaneous displacement, thus causing a subluxation of the lower jaw.

Dislocation

Genuine dislocations are always forwards, and all the muscles of mastication assist in maintaining the displacement. The external pterygoids draw the jaw forwards, and the masseter, temporal and internal pterygoid muscles draw it upwards in front of the eminentia articularis. The inter-articular fibro-cartilage remains attached to the condyle till it has passed the eminentia, but is then left behind (Treves).

Violent blows backwards on the chin may drive the head of the jaw against the bony wall of the auditory meatus and fracture one or both of the bones.

Hare lip

Since the upper lip is formed by the junction of the covering of the lateral maxillary processes with

the fronto-nasal process, or rather with its globular processes, failure of such union on one or both sides results in a single or double hare-lip. The columna or portion of the lip beneath the septum nasi is the part developed from the fronto-nasal process. If the failure to unite extends to the deeper parts, the pre-maxilla is found separated from the maxilla and its palatal process on one or both sides by a fissure passing from the interval between the lateral incisor and the canine to the middle line of the hard palate.

Cleft palate

If the palatal processes are undeveloped and one or other does not reach the vomer, cleft palate, complete or only involving the soft palate results. A bifid uvula is the least degree of this deformity.

The height and width of the arch of the hard palate are matters of moment in the operation for closure of a cleft, since the higher the arch the more readily can the flaps be brought across to meet in the middle line. On the other hand, a narrow, high arch, means an ill-developed nasal cavity and a narrow basis cranii, and therefore obstruction to respiration and possibly impaired brain growth.

Sometimes the palate process reaches the vomer on one side; the cleft palate would be then single; if it failed to reach the middle line on both sides the cleft would be double, but considerable variations are met with in this respect.

The pre-maxilla usually carries the four incisors, but often the lateral ones fail to develop, being as it were lost in the cleft where severe hare-lip occurs,

or these teeth may be distorted or misplaced and rotated.

The tuberosity of the superior maxilla can be felt behind the last upper molar tooth, and a little higher up and posterior to this is the hamular process of the internal pterygoid plate.

Palatal muscles

An incision from this process forwards and inwards to the middle of the posterior border of the hard palate will divide the tensor and levator palati muscles, and thus give rest to the part in cleft palate operations.

Posterior palatine canal. Vessels and nerves

Opposite the last molar tooth, in the angle between the alveolus and hard palate is the lower orifice of the posterior palatine canal, and from this issue the posterior palatine artery and anterior palatine nerve, which run forward towards the incisors in a line nearer the side than the middle of the palate. Consequently, the incisions which are made through the muco-periosteum of the hard palate to facilitate the raising of it from the bone, and the approximation of the edges in cleft palate, should not be nearer the alveolus than the edge of the cleft, or better still, should be close to the alveolus so as to include the vessels in the flap.

Floor of mouth

"Tongue-tie" is not a rare condition, though not so common as nurses would have it. In the middle line the frænum linguæ stretches from the posterior surface of the lower jaw to the under surface of the tip of the tongue. It is best divided, if too tight, by a snip close to the jaw, and subsequent tearing. The scissors should be kept close to the bone to avoid the ranine vessels of which the veins can be seen

beneath the mucous membrane. The arteries lie close to them but deeper.

Wharton's ducts On each side of the middle of the frænum are seen the papillæ on which open the orifices of the submaxillary ducts.

Sublingual glands The ducts run outwards over two ridges which contain the sublingual glands.

Ranula When the ducts of the latter (ducts of Rivini and Bartholin) are blocked and distended, one form of ranula is produced, and the ducts of Wharton run upon the surface of the tumour, but are not connected with it. A ranula is usually formed by the dilatation of one of the small mucous glands in the floor of the mouth. Blocking of the ducts of Nuhn's or Blandin's glands, which lie on each side of the under surface of the tip of the tongue, may cause a cystic swelling.

Bursæ in floor of mouth A bursa is mentioned by Sir W. Treves, on the authority of Tillaux, as being sometimes found beneath the front of the tongue between the genio-hyo-glossi muscles and the mucous membrane. An enlargement of this bursa would also constitute a form of ranula.

Dermoids are sometimes found in the sub-mental space, as sequestration cysts included in the closure of the branchial cleft.

Lingual nerve The pterygo-maxillary ligament can be seen and felt behind the last molar tooth of the lower jaw. The lingual nerve is just below and in front of the lower attachment of the ligament, and lies close to the bone below the last molar. It may be divided here to give relief to incurable cancer of the tongue

by an incision in a line from the last molar tooth to the angle of the jaw, or it may readily be found by an incision along the line of reflection of the mucous membrane from the jaw to the tongue.

If the cancer involves the posterior third of the tongue, division of the lingual will not give relief, as this part is supplied by the glosso-pharyngeal nerves.

Coronoid process

The coronoid process can be felt behind the last lower molar, and through the interval between them a feeding tube can be passed when the lower jaw is fixed from any cause.

Temporal abscess

Internal to the coronoid and between it and the tuberosity of the superior maxilla is a recess where a temporal abscess which has failed to pierce the temporal fascia and has travelled down the tendon of the muscle may point in the mouth.

Inferior dental nerve

The trunk of the inferior dental nerve, as it enters the foramen in the ascending ramus of the lower jaw, lies between the bone on the outer side and the internal lateral ligament and internal pterygoid muscle on the inner side.

Division through the mouth

It may be reached by a vertical incision through the mucous membrane from the last molar tooth of the upper jaw to that of the lower, carried downwards just on the inner side of the ridge that marks the anterior border of the ramus. On forcing the finger backwards between the internal pterygoid muscle and the bone, the spine at the entrance to the dental canal can be felt and the nerve may be caught up and stretched or divided just before it enters the foramen.

The nerve can also be reached by trephining the ramus of the jaw and enlarging the sigmoid notch, or by an incision along its posterior border corresponding to the insertion of the masseter. The internal pterygoid is separated from the bone and the nerve thus found.

Care is needed in the trephining operation to avoid fracture of the jaw, and the nerve is not always so readily found as might be supposed. The lingual nerve will be found a little deeper than and a little in front of the inferior dental.

Tongue On the dorsal surface of the tongue the circumvallate papillæ form a V-shaped figure with the angle backwards.

Foramen cæcum Just behind the apex of the V is the orifice of the foramen cæcum, the persistent upper end of the primitive thyro-glossal duct of His.

Thyro-glossal duct Occasionally this canal remains patent in a portion of its length, forming a passage which can be traced down as far as the hyoid bone. The persistence of this duct and the blocking of its lumen may give rise to deep-seated cysts beneath the tongue, or malignant tumours may take origin in its lining epithelium. The foramen cæcum is by no means constant in the adult.

Glosso-epiglottic fold Behind the foramen, the glosso-epiglottidean fold of mucous membrane passes from the tongue to the anterior surface of the epiglottis. A ligature passed through this serves to draw forward the stump left after excision of the tongue, and may assist in dealing with hæmorrhage. The divided ends of the lingual arteries appear on the stump of the tongue

external to the genio-hyoglossi muscles. It is to be remembered that one artery may be much larger than the other.

The dilatation of the lymphatic vessels of the tongue sometimes results in the vast increase in the size of the organ to which the term macroglossia is applied. **Macroglossia**

The lingual lymphatics after leaving the tongue, enter one or two glands on the hyoglossi muscles in the submaxillary triangle before passing to the deep glands of the neck. Hence these are first involved in secondary cancerous deposit. An infected lymph gland will often be found imbedded in the submaxillary salivary gland.

The tongue receives its motor and trophic nerve fibres through the hypo-glossal nerve. Hence injury to that trunk at the anterior condyloid foramen or elsewhere, or affection of the hypo-glossal nucleus, as in bulbar paralysis, may result in paralysis or atrophy of the tongue on one or both sides. **Nerve supply**

The adenoid tissue (lingual tonsil) between the tongue and epiglottis may become hypertrophied and hamper the movements of the latter. This is said to usually occur in conjunction with ordinary enlargement of the tonsils. **Lingual tonsil**

In the anterior and posterior pillars of the fauces lie the palato-glossus and palato-pharyngeus muscles respectively, and running up in the anterior pillar is a branch of the ascending pharyngeal artery. The pillars may require division in operations for removal of the tongue, and sometimes the anterior pillar is divided to **Fauces**

help in relaxing the tension of the soft palate in palatoplasty.

Tonsils The tonsils lie between the anterior and posterior pillars of the fauces overlapped by the former to an extent varying with the development of the palato-glossus muscle. The angle of the jaw corresponds to their position, but they cannot be felt externally even when enlarged, though an enlarged lymphatic gland lying on the outer aspect of the tonsil is readily felt from the exterior, and is sometimes mistaken for the tonsil. The tonsils are separated by the pharyngeal aponeurosis from the internal carotid and ascending pharyngeal arteries, the former being about three-quarters of an inch posterior to the tonsil and not likely to be wounded. The glosso-pharyngeal nerve is close outside the gland, and supplies it with sensory fibres. Hilton has noticed, as recorded by Jacobson, that furring of the posterior third of the tongue may be a trophic change due to an inflamed tonsil—the tonsil and posterior third of the tongue having the same nerve supply. The bleeding, which very occasionally occurs after tonsillotomy, usually comes from tonsillar branches of the ascending pharyngeal, dorsalis linguæ, internal maxillary and facial arteries.

Follicles of tonsil The crypts upon the surface of the tonsils are of importance as affording lodgment for decaying organic matter which may set up follicular tonsillitis or even suppuration and are the occasional seat of small calculi. The lingual, faucial and pharyngeal tonsils form a ring of lymphoid tissue

round the faucial aperture, and probably this is a provision for protection of the organism against poisonous and irritating invaders. The mucous secretion of the glands in the crypts acts not only as a lubricant, but serves to entangle noxious matters which may then be dealt with by the lymphatic tissue of the tonsils in the same fashion that lymphatic glands elsewhere deal with poisons in the tissues. The lymphatic tissue of the appendix vermiformis similarly appears to form the "tonsil" of the junction between the large and small intestines. In each case the protecting apparatus is prone to inflammation itself as the price of saving the rest of the body.

Abscess

An enlarged and inflamed tonsil is sometimes found to extend upwards between the layers of the soft palate, pushing the latter forwards, and an abscess of the gland can then best be opened by making a vertical incision through the bulging portion of the palate.

In the operation for removal of enlarged tonsils it is not uncommon to find that the whole tonsil has been enucleated entire, especially if the operation has been done with a somewhat blunt guillotine.

Pharynx

The pharynx extends from the fauces to the sixth cervical vertebra, where it joins the gullet. This latter point is about six inches from the front teeth, and is the site of the first constriction and a probable locality for impaction of foreign bodies. The basal part of the occipital bone, the posterior part of the body of the sphenoid and the anterior aspects of the first four cervical vertebræ can be examined

with the finger by way of the pharynx. The anterior arch of the atlas is level with the hard palate, and the body of the axis with the edge of the upper teeth.

On the surface of the posterior pharyngeal wall are often seen rounded salmon-coloured patches of adenoid tissue constituting "granular pharyngitis."

Pharyngeal tonsil These often co-exist with enlargement of the pharyngeal or Luschka's tonsil, which occupies the posterior wall between the Eustachian orifices and spreads on to the roof of the cavity. Its hypertrophy in children may produce all the symptoms of ordinary enlarged tonsils and forms the condition known as post-nasal adenoid vegetations.

Prevertebral lymphatic gland A lymphatic gland lies in the prevertebral fascia at the back of the pharynx and receives vessels from the nares and pharynx. It may be enlarged or form an abscess as a result of irritation about those parts, and we have known an abscess from this cause give rise to such urgent dyspnœa that instant tracheotomy was necessary.

Post-pharyngeal abscess A collection of pus between the pharynx and spine due to suppuration in this gland or to phlegmonous inflammation about the pharynx may be opened by incising the posterior pharyngeal wall through the mouth.

Cervical caries An abscess due to caries of the cervical vertebræ or to any cause promising long suppuration is best opened from the side by an incision behind the sterno-mastoid. Unless free exit is given, the pus may burrow forwards round the pharynx, or downwards into the posterior mediastinum.

The nasal fossæ are roughly wedge-shaped in form, with the base below and the apex above; the inner wall is nearly flat and the outer concave with projections from it of the turbinated bones. As a result of this formation of the nasal fossæ, removal of polypi or foreign bodies by forceps is best managed by opening the instruments vertically and not transversely.

Nares

On inspection of the anterior nares the anterior end of the inferior turbinated bone covered with spongy erectile tissue is conspicuous, and above and behind it is less distinctly seen the anterior part of the middle turbinated. The middle and inferior fossæ and the septum are thus open to inspection from the front.

Posterior nares

The posterior ends of the inferior and middle turbinate bones are palpable through the posterior nares. These orifices measure about one inch by half an inch. This point is useful to know when making a plug to stop them.

Nasal duct

The *nasal duct* opens into the top of the lower meatus, about an inch behind the anterior nares and three-quarters of an inch from the floor of the cavity.

Orifice of antrum

On the lateral wall of the middle meatus is a deep curved groove, running from above downwards and backwards, which is known as the hiatus semilunaris, with the bulla ethmoidalis above it. Opening into the back part of this groove, midway between the anterior and posterior nares, is the slit-like orifice of the antrum of Highmore. As this aperture is placed nearer the roof than the

floor of the antrum, the escape of fluids which may collect within that cavity is rendered difficult.

Ethmoidal cells The anterior ethmoidal cells open into the front part of the hiatus. The middle ethmoidal cells open into the middle meatus a short distance above the orifice of the antrum. The middle meatus is directly continuous above and in front with the frontal sinus by means of a narrow channel known as the infundibulum.

The *posterior ethmoidal cells* open far back beneath the superior turbinated bone, *i.e.*, in the superior meatus.

Sphenoidal sinus The *sphenoidal sinus* opens into the back part of the general cavity near the roof. Through these openings the lining of the nasal cavities is continuous with that of the various sinuses, which thus readily share in nasal catarrh. Further, the orifices may be blocked by nasal polypi, and dropsy of the cavities may be produced or "epiphora" if the nasal duct be obstructed. The horizontal plate of the ethmoid forming the roof of the nasal cavities is "cribriform" and may allow inflammatory processes to spread from the nose to the cerebral meninges.

Epistaxis The communication through the foramen cæcum between the superior longitudinal sinus and the upper nasal veins explains the relief afforded to cerebral congestion by epistaxis.

Septum nasi The cartilaginous nasal septum is normally usually deflected from the middle line, but exaggeration of the deflection or spur-like lateral outgrowths encroaching upon the nares often cause obstruction to respiration.

Eustachian tube

The orifice of the Eustachian tube opens on the upper part of the side of the pharynx on a level with the inferior meatus of the nose. The upper margin of the orifice is half an inch in front of the posterior pharyngeal wall, and the same distance above the soft palate. The tube is nearly two inches long, and slopes backwards, outwards and upwards from the pharyngeal aperture. The tensor palati opens the orifice during the act of swallowing. The mucous membrane of the pharynx is continuous with that lining the tympanum, and catarrh of the one cavity may spread to the other, or obstruction of the pharyngeal orifice cause deafness.

Frontal sinuses

The frontal sinuses occupy the bone above the inner angle of the orbit and the adjacent part of the glabella. Their lining membrane is continuous through the infundibulum with that of the middle meatus. Hence inflammation readily spreads from one to the other, and the tissues round a fracture of this part of the frontal bone may be the seat of emphysema. The sinuses may readily be opened through their inferior wall at the inner part of the orbit. The variations in development of the sinuses must be borne in mind; thus they do not exist in childhood.

Lachrymal apparatus

On pressing the finger just below the inner angle of the palpebral fissure the hollow in the lachrymal bone, in which lies the lachrymal sac, can be felt. The tendo oculi crosses the front of the sac rather above its centre, leaving one-third of the sac above

and two-thirds below the tendon. The angular artery runs up on the nasal side of the sac.

Canaliculus The orifice of the canaliculus, "punctum lachrymale," in each lid is seen on the summit of a papilla, a short distance from the inner canthus. To allow a probe to enter the canaliculus the eyelids should be drawn outwards so as to straighten out the angle in the duct which exists at the papilla.

Nasal duct The lachrymal duct runs downwards, backwards and outwards, to its orifice in the inferior meatus, so that a probe must take this direction when passed down it.

Abscess of sac When the lachrymal sac suppurates and the duct is obstructed, the opening into the sac is made below the tendo-oculi.

Eyelids The Meibomian glands lie beneath the palpebral conjunctiva. Obstruction to their ducts causes "tarsal cysts." The follicles of the eyelashes or the contiguous sebaceous glands may be the seat of local inflammations causing "stye."

The loose, fatless cellular tissue of the eyelids is readily filled with fluid, hence the œdema seen in renal disease, etc., and the collection of blood which constitutes "black eye."

Suspensory ligament of eyeball That portion of the capsule of Tenon which passes beneath the eyeball is attached internally to the lachrymal bone and externally to the malar forming the suspensory ligament of Lockwood, which, if its attachments are preserved, prevents the globe from dropping downwards after complete excision of the superior maxilla.

Orbital tumours

The "pulsating tumours" which occupy the orbit and push forward the eyeball are usually due either to dilatation of the intra-cranial part of the internal carotid artery, to arterio-venous aneurism between the carotid and cavernous sinus, to intra-cranial aneurism of the ophthalmic artery, or to thrombosis of the cavernous sinus. Some, of course, are vascular growths.

Nerves

The third, fourth, ophthalmic division of the fifth and the sixth cranial nerves all enter the orbit through the sphenoidal fissure. They may be pressed upon and paralysed by orbital tumours, periostitis of the bony margins of the fissure, intra-cranial carotid aneurisms, tumours of the pituitary gland, etc. The third nerve supplies all the orbital muscles except the superior oblique and external rectus which are supplied by the fourth and sixth nerves respectively. The fifth nerve supplies fibres of common sensation to the eyelids and eyeball as well as trophic fibres to the latter; hence injury to it is liable to be followed by inflammation and wasting of the globe, one of the objections to removal of the Gasserian ganglion for inveterate neuralgia.

Scalp
Superficial fascia

The superficial fascia of the scalp is dense and tough, consisting of fibrous septa containing pellets of fat packed in vertical columns. It is closely adherent to the skin above and the aponeurosis of the occipito frontalis below. Sliding is impossible between these three layers, and hence wounds of the scalp which do not penetrate the aponeurosis of the muscle never gape widely.

Aponeurosis

The aponeurosis, together with its occipital and

frontal muscles, extends from the supra-orbital ridge to the superior curved line of the occipital bone, to which it is attached. Laterally it is continuous with the temporal fascia along the temporal ridge of the parietal and to the mastoid process.

Cellular tissue

The subaponeurotic connective tissue is loose and open, allowing sliding of the aponeurosis over the pericranium and wide gaping of wounds which divide the three outer layers of the scalp. This tissue admits of extensive infiltrations of blood or inflammatory material into its meshes, and is hence called the "dangerous area." An insufficiently drained or a septic wound involving this layer may cause swelling of the scalp within the boundaries of the aponeurotic attachments extending forward to the eyelids, or beneath the temporal fascia to the zygoma laterally. The cellular tissue readily sloughs, and a purulent infiltration becomes one large abscess. This layer is the seat of the "caput succedaneum" of the newly-born, while

Cephalhæmatoma

"cephalhæmatoma" is a collection of blood beneath the pericranium, and hence limited to the area of a single bone by the attachment of the pericranium along the sutures.

Vessels of Scalp

The *arteries* and *veins* of the scalp run in the superficial fascia above the aponeurosis. The toughness of this tissue renders impossible retraction or incurling of the vessel walls in a wound. Consequently bleeding is free. The end of the vessel is difficult to seize or ligature, while an attempt to stop the bleeding by pressure may cause sloughing of the scalp unless care is exercised.

The *pericranium* is readily stripped from the skull except along the sutures where fibrous bands pass between it and the dura mater. Since the bones are nourished mainly from the dura mater the pericranium can be extensively stripped without necrosis following; but when necrosis does occur the bone is not often perfectly reproduced. **Pericranium**

Inflammation can readily pass from one layer of the scalp to another, and so on to the meninges and brain through the *emissary veins* which perforate the skull, and by means of the diploic veins which open into the sinuses of the dura mater, and communicate with the veins of the scalp. Similar conditions may arise about the face and the base of the skull. The most constant emissary veins are:— **Emissary veins**

1. One through the mastoid foramen between the lateral sinus and the occipital or posterior auricular veins. Pus can sometimes be seen issuing from this foramen when the mastoid process has been exposed in trephining over the lateral sinus in cases of septic thrombosis. **Mastoid**

2. One through the foramen cæcum between the superior longitudinal sinus and the veins of the nasal mucous membrane. The significance which this gives to some cases of epistaxis has been noticed. **Nasal**

3. One through the parietal foramen from the superior longitudinal sinus to the veins of the scalp. **Parietal**

4. One through the anterior condyloid foramen from the occipital sinus to the vertebral veins and the plexus on the front of the spine. **Anterior condyloid**

Posterior condyloid 5. One through the posterior condyloid foramen from the lateral sinus to the beginning of the vertebral vein.

Ophthalmic 6. The ophthalmic vein which establishes communication between the cavernous sinus and the angular vein of the face, and may become infected with septic matter from cellulitis of the face.

Pterygoid 7. Veins which pass through the foramen ovale between the cavernous sinus and the pterygoid and pharyngeal plexuses.

Supraorbital artery The position of the *supra-orbital nerve* and *artery* has already been noticed. They are distributed as high as the vertex.

Superficial temporal artery The superficial temporal artery crosses the zygoma just in front of the tragus and divides about two inches above the bony ridge. It could readily be ligatured where it crosses the zygoma, and here also the pulse may readily be felt during the administration of chloroform. This vessel is occasionally the seat of cirsoid aneurism. The

Occipital artery *occipital* becomes superficial on the scalp rather nearer the external occipital protuberance than the

Posterior auricular mastoid process. The *posterior auricular* artery lies close behind the pinna, and is often wounded in the incisions made for opening up the mastoid antrum.

Mastoid gland A lymphatic gland lies over the mastoid process, and inflammation or suppuration occurring in it might be mistaken for the pointing of an abscess taking origin within the bone.

Sub-occipital glands The alleged proneness of the suboccipital glands to enlargement in secondary syphilis may be remem-

bered; they are often the seat of inflammation from scalp irritation.

Pinna

The auricle may present abnormalities due to the want of fusion of the six primitive tubercles from which it is built up. These take the form of small superficial clefts or fistulæ at the site of the fissures between the tubercles. A fistula of greater or less extent, with or without a supernumerary auricle near it is often found just in front of the helix or tragus. The auricle is often the seat of sub-cuticular gouty deposits and in the insane of hæmatomata which occur spontaneously.

Tophi and hæmatomata

Auditory meatus

The external auditory meatus has a total length of about one and a quarter inches, of which the outer half inch is cartilaginous, and the inner three-quarters osseous. The canal has a general direction inwards and forwards, but at the junction of the cartilaginous and osseous portions it is slightly bent in such manner that it is necessary to draw the pinna upwards and backwards in order to straighten the channel. This is accordingly done when a speculum is passed. In its outer part the tube is widest in its vertical diameter, but the horizontal diameter is greatest at the inner end. Owing to the obliquity of the membrana tympani, the floor of the canal is longer than the roof, and the anterior wall longer than the posterior.

Nerves

The upper part of the outer surface of the pinna and the auditory canal are supplied by the auriculo temporal branch of the fifth nerve. The lobule and part of the posterior margin by the second cervical nerve. The cranial surface is supplied by the

great auricular from the second and third cervical nerves, and over its lower part by the auricular branch of the vagus with an occasional twig from the small or the great occipital to the inner side of the tip of the ear.

The bearing of these nerve distributions upon the conjunction of ear pain with affections of the teeth and tongue, and of laryngeal and gastric symptoms with irritation in the auditory meatus has already been noticed.

Mastoid Antrum

The mastoid sinuses communicate with the middle ear through the antrum, which is larger than they are and opens into the tympanum at the upper and posterior part. The antrum is a part of the tympanic cavity and not one of the mastoid cells, hence it is present in early infancy, and is at first near the surface. As the mastoid process grows in size the cavity recedes from the surface and the mastoid cells appear, extending over the roof of the meatus and reaching back to the occipito-mastoid suture. Since the lining membrane of the antrum is continuous with that of the tympanum it shares in suppurative disease of the latter.

Veins pass from the antrum to open into the lateral sinus; hence septic thrombosis may follow mastoid disease.

Petro-squamous suture

The petro-squamous suture passes across the roof of the antrum, and through this veins run to join the vessels of the dura mater. Other veins from the mastoid cells pass through the mastoid foramen to join the occipital and other scalp veins. Thus mastoid disease may be followed by meningitis and

cerebral abscess or by inflammations of the parts outside, *e.g.*, periostitis of the bones, cellulitis of the scalp, etc.

Distance of antrum from surface

A needle driven into the bone close behind the pinna, and on a level with the roof of the auditory meatus would enter the mastoid antrum at a depth varying from two lines in the infant to half or three-quarters of an inch in the adult.

Opening the antrum

In opening the antrum the instrument is applied at the point of intersection of two lines; one drawn vertically upwards through the tip of the mastoid, the other horizontal and level with the roof of the meatus. The point is indicated by a small triangular pit or depression which can be seen on the surface of the bone as soon as the soft parts are retracted (Macewen). The instrument should travel in a direction parallel to the auditory canal.

The antrum is about the size of a pea. The layer of bone separating its roof from the middle fossa of the cranial cavity is about one twenty-fifth of an inch thick, and the posterior end of the cavity is only one-eighth to one-quarter of an inch in front of the lateral sinus.

Lateral sinus

The Lateral sinus runs in a line from the occipital protuberance to the base of the mastoid, reaching a point one and a half inches behind and three-quarters of an inch above the centre of the auditory meatus, where it bends downwards, grooving the mastoid process about half an inch behind the posterior margin of the meatus.

The sinus may be opened on a level with the upper part of the auditory meatus about three-

quarters of an inch behind the attachment of the pinna. The mastoid vein perforates the bone a little further back still. In disease of the middle ear four of the most common complications, mastoid abscess, thrombosis of the lateral sinus, subdural abscess and temporo-sphenoidal abscess may all be reached within the circumference of a space the size of a florin. By removing bone a little further back the tentorium could be reached, and a cerebellar abscess tapped through it.

The cerebellum is best exposed in a formal operation by applying a trephine at a point one and a half inches behind the centre of the auditory meatus and one inch below Reid's "base line."

Temporal fossa The fascia covering the temporal fossa is strong and firmly attached to the zygoma and temporal ridges. Hence pus formed beneath the fascia is apt to burrow downwards into the pterygo-maxillary region and side of the neck. Its occasional bursting at the back of the mouth between the coronoid process and the superior maxillary bone has been noticed.

Cranial bones The cranial bones have certain peculiarities which influence their behaviour when subjected to violence. Thus their combination to form a globular figure renders them able to withstand greater violence than would their individual strength. The force is broken up by radiation in different directions, and the sutures tend to deaden the vibrations as they travel. The bevelling and overlapping of the edges of bones is so arranged that mutual support is afforded. Thus the frontal

bone overlies the parietals at the inner parts of the coronal sutures, whilst the reverse is the case at the outer parts. Hence blows upon the middle of the head over the frontal or parietal bones would tend to force outwards the lower parietal margins. But these in turn are overlapped by the great wings of the sphenoid and squamous plates of the temporal bones, and are thus kept in. The local thickenings and ridges are so arranged as to give additional support. Such are the internal longitudinal ridge from the occiput to the nose, the mastoid processes and petrous parts of the temporal bones and the ridge between the mastoid processes, along the line of the lateral sinuses. Externally, the skull is strengthened by the supra-orbital ridges, the temporal ridges, the zygomatic arches and the malar bones.

It is in part due to the radiation of the violence that the internal table of the skull is often more widely fractured than the external, or may be the only one broken.

Fractured base

Force applied to vault

Fractures of the base of the skull following violence applied to the vault of the cranium usually occur in a situation corresponding to the part of the vertex injured. Thus blows upon the frontal region may result in fracture of the anterior fossa, blows upon the parietal in fracture of the middle fossa, and blows upon the occipital in fracture of the posterior fossa—that is, the fracture of the vertex tends to travel downwards to the base in a straight line, but its course is modified by the lines of strength above mentioned.

Force applied to chin

Blows upon the chin may be transmitted through the condyles of the lower jaw and may fracture the middle fossa. Violent falls upon the feet when all the joints are extended and the body rigid may fracture the posterior fossa by transmission of the force to the occipital condyles.

Force transmitted through spine

Fractures of the anterior fossa are very commonly compound owing to tearing of the nasal mucous membrane below the cribriform plate of the ethmoid. Bleeding from the nose or vomiting of swallowed blood after an injury to the head should always suggest the possibility of fracture of the base of the skull, either of the anterior or of the middle fossa. Bleeding takes place into the orbital cavity, and if copious, the blood appears beneath the ocular conjunctiva and infiltrates the tissues of the eyelids.

The blood can pass most readily from the back of the orbit to the outer canthus, and an extravasation extending forwards here is suggestive of fracture, while a collection due to mere local contusion will, when the eyeball is directed inwards, be seen to become gradually less marked posteriorly (Lucas).

Fractures of the middle fossa may be rendered compound by rupture of the tympanic membrane, tearing of the lining membrane of the pharynx, or fracture into the sphenoidal air cells which communicate with the nose.

Cerebro spinal fluid

The discharge of cerebro-spinal fluid sometimes seen coming from the nose after fracture of the anterior fossa is probably due to a fracture of the horizontal ethmoid plate which has opened up the subarachnoid space by tearing the prolongation of

that membrane which surrounds the olfactory nerve filaments. A like discharge from the ear is usually due to rupture of the arachnoid *cul-de-sac* which surrounds the auditory nerve in the internal auditory canal. The fluid then percolates through the fracture of the bone and issues from the tear in the tympanic membrane. In fracture of the posterior fossa there may be a suboccipital hæmatoma.

Sutures

The sutures between the cranial bones are not of great value in determining the position of the various convolutions in the living subject, but several are useful in other ways.

Bregma

The *bregma* is in the middle line of the cranium just in front of a line drawn transversely over the vault from one external auditory meatus to the other. Here the sagittal and coronal sutures join, and the anterior fontanelle exists in infancy.

Lambda
Inion

The *lambda*, two and three-quarter inches above the external occipital protuberance ("inion"), is the site of the posterior fontanelle in infancy and marks the junction of the sagittal and lambdoid sutures.

Pterion

The *pterion* or junction between the frontal, parietal, temporal and sphenoid bones is in the temporal fossa one and a half to two inches behind the external angular process of the frontal bone, and about the same distance above the zygoma. A Wormian bone is sometimes found here. The point marks the anterior inferior angle of the parietal bone, which is grooved by the anterior branch of the middle meningeal artery, and here a trephine is applied in cases of hæmorrhage from that vessel.

Middle meningeal artery

Asterion The *asterion*, where the lambdoid and parieto-mastoid join, is half an inch above and three-quarters of an inch behind the upper end of the posterior border of the mastoid. It indicates the posterior inferior angle of the parietal bone, which is grooved by the lateral sinus. The relation of this point to the auditory meatus has been noted in connection with mastoid disease.

Naso-frontal suture The *naso-frontal suture* in the groove between the nose and forehead is a more constant and definite point for measuring from than the glabella, which varies greatly in size.

Bony defects Various abnormal openings may occur as a result of defective development of the cranial bones, through which the meninges, or even parts of the brain, may form hernial protrusions. The most usual sites for such are in the middle line of the occipital bone between the foramen magnum and the lambda, where the primitive fissure, which separates the two halves of the bone, has persisted to a greater or less extent; through the frontal at the root of the nose, and occasionally through the cribriform plate of the ethmoid into the nasal cavity.

Dura mater The dura mater is not very firmly attached to the bones over the vault of the cranium, but is closely adherent over the base. It may be detached from the vault by a blow on the outside of the head. Blood rapidly fills the space thus formed, and may injuriously press upon the brain. The artery most frequently injured in fracture of the vault is the anterior branch of the middle meningeal. If this or any considerable artery communicates with a

collection of blood between the dura mater and skull, the blood-pressure in the vessel, acting equally in all directions through the mass of blood, easily exerts sufficient force to separate the dura mater still more extensively from the bone. Hence such hæmorrhage should be dealt with quickly. The position of the middle meningeal artery has been pointed out.

Superior longitudinal sinus

The superior longitudinal sinus runs in the middle line from the glabella to the external occipital protuberance; hence in operations on the skull the parietal bone must not be divided within half an inch of the middle line.

Arachnoid

The arachnoid membrane sends prolongations upon the olfactory, optic and auditory nerves, and the subarachnoid space is continuous with the perineural lymph spaces. The bearing of these facts upon discharge of cerebro-spinal fluid in fractures of the skull has already been noticed.

Subarachnoid space

The subarachnoid space communicates with the cavities of the brain through the foramen of Majendie in the middle line of the roof of the fourth ventricle and by the foramina of Key and Retzius in the lateral recesses, behind the upper roots of the glosso-pharyngeal nerves. By these openings the fluid secreted by the lining membrane of the cerebral ventricles escapes into the general lymphatic system. If they become occluded, distension of the cavities results. Such occlusion, however, is not found in all cases of hydrocephalus.

Subarachnoid fluid

The subarachnoid space is most capacious between the under surface of the cerebellum and the medulla

oblongata and beneath the base of the brain in the posterior and middle fossæ. The brain rests directly upon bone only in the anterior and the front of the middle fossæ; elsewhere the subarachnoid fluid forms a "water bed" for the encephalon, thus deadening shocks and minimising friction.

Tentorium cerebelli It is to be noted that most of the weight of the posterior parts of the hemisphere is borne, not by this water bed, but by the tentorium cerebelli, which acts as an elastic hammock for these parts, thus preventing pressure from above on the cerebellum, medulla and pons.

The subarachnoid spaces round the brain and cord are continuous through the foramen magnum; hence pressure on a spinal meningocele increases the tension in the cranial cavity, producing drowsiness or convulsive symptoms.

Topography The various fissures and convolutions of the brain are thus mapped out upon the scalp.

Great longitudinal fissure The *great longitudinal fissure* in the median line, from the root of the nose to the external occipital protuberance.

Sylvian fissure *The fissure of Sylvius.* A line from a point one and a quarter inches behind the external angular process of the frontal bone and about the same distance above the zygoma to a point three-quarters of an inch below the parietal eminence. The first three-quarters of an inch will represent the main fissure and the rest of the line the horizontal limb.

Naso lambdoidal line The ascending limb will be represented by a line passing vertically upwards for one inch from the

posterior end of the line indicating the main fissure.

The *fissure of Rolando* is determined in different ways. **Fissure of Rolando**

Reid draws a "base line" round the head on a level with the lower margin of the orbit and passing through the centre of the external auditory meatus. From this line two perpendiculars are drawn to the vertex—one from the depression in front of the meatus, the other from the upper end of the posterior border of the mastoid process. The fissure of Rolando is in a line joining the point where the posterior perpendicular cuts the great longitudinal fissure with the point where the anterior vertical line cuts the horizontal limb of the fissure of Sylvius. The fissure itself starts in the middle line, and is $3\frac{3}{8}$ inches long.

Another method of determining this fissure is to take a point half an inch behind the mid distance between the naso-frontal groove and the external occipital protuberance. The fissure follows a line drawn downward and outwards from this point for $3\frac{3}{8}$ inches at an angle of 70° (Hare) or 71° (Cunningham) with the median line of the head.

The *ascending frontal convolution* occupies a zone three-quarters of an inch wide in front of and parallel with the fissure of Rolando. The rest of the frontal lobe is divided into *superior*, *middle* and *inferior frontal convolutions* by two lines—one drawn upwards from the supra-orbital notch parallel to the median line and ending three-quarters of an inch in front of the fissure of Rolando, the other **Convolutions** **Ascending frontal**

drawn along the temporal ridge from the external angular process of the frontal bone and ending at a like point to the preceding line. The third frontal convolution is between this line and the Sylvian fissure.

Ascending parietal The *ascending parietal convolution* lies behind the fissure of Rolando throughout its whole length.

Angular gyrus The *angular gyrus* lies behind and contiguous to the supra-marginal lobe.

Temporo-sphenoidal lobe. The *temporo-sphenoidal lobe* lies between the Sylvian fissure and its horizontal limb above and the upper border of the zygoma and its continuation backwards below. The posterior boundary of the lobe is a slightly convex line with the convexity directed backwards, drawn from a point midway between the posterior border of the mastoid process and the inion, to the posterior end of the horizontal limb of the fissure of Sylvius. The superior and middle temporal fissures, parallel to the fissure of Sylvius divide the lobe into *superior*, *middle* and *inferior temporo-sphenoidal convolutions.*

The tip of the temporo-sphenoidal lobe reaches forwards as far as the posterior superior border of the malar bone in front of the temporal fossa.

Occipital lobe The *occipital lobe* occupies the space between the inner half of the superior curved line below, the parieto-occipital fissure above, the great longitudinal fissure internally and the temporo-sphenoidal lobe in front. It is not separated by any conspicuous fissure from the angular gyrus of the parietal lobe.

The position of the motor and sensory areas on the cortex are of importance as helping to localise

lesions which produce paralysis by destruction of the areas or spasms or convulsions by irritation of them. They are, however, still not certainly established. Cortical areas

Motor area for tongue and lips in movements of speech. The posterior end of the third left frontal convolution, posterior to the vertical limb of the Sylvian fissure and merging into the facial area (Broca's convolution). Speech

Area for facial movements. Lower and middle thirds of ascending frontal (and lower end of ascending parietal convolution). Face

Area for the arm. Upper part of ascending frontal (middle third of ascending parietal), and posterior end of the superior frontal convolution. The hand movements are represented lowest down in this area, the elbow movements nearer the middle line and the shoulder movements highest up. Arm

Area for the leg. Upper ends of both ascending frontal (and ascending parietal convolutions) and the median and anterior portion of the superior parietal lobule. Leg

Area for movements of trunk, scapula and hip joint. The motor portion of the marginal gyrus on the mesial surface of the hemisphere; that is, the para-central lobule or part opposite the upper ends of ascending frontal and parietal convolutions, and part of the quadrate lobe just behind this. Trunk, Scapula hip joint

The *visual area* occupies the occipital lobes and the contiguous parts of the supra-marginal and angular gyri. Visual area

Auditory centre The *auditory cortical area* occupies the posterior end of the superior temporo-sphenoidal convolution.

It will be seen that the motor areas around the fissure of Rolando overlap one another to some extent. Still, broadly speaking, the parts round the lower end of the fissure correspond to the face, about the middle of the fissure to the arm and about the upper end to the leg.

Centres whose importance is less often seen clinically are said to exist in the posterior ends of the upper two frontal convolutions governing movements of rotation of the head and eyes. Certain head movements are also represented on the corresponding part of the mesial surface of the hemisphere in front of the area for the trunk, scapula and hip.

NOTE.—The assignment of motor functions to the ascending parietal convolution has been put in brackets since it appears probable from the work of Sherrington and others that the "motor area" here does not extend behind the fissure of Rolando.

THE TEETH.

Dentition The process of dentition commences about the sixth month after birth, and the temporary teeth are normally erupted by the end of the second year of life. The teeth usually appear in the following order:—Central incisors, lateral incisors, first molars, canines, second molars.

Rickets
Syphilis

The appearance of teeth is often delayed in rickets, and sometimes accelerated in congenital syphilis. One or two teeth may be present at birth.

Disorders of dentition

The extensive origin of the fifth cranial nerve from the floor of the aqueduct and the fourth ventricle and as far down the cord as the fourth cervical nerve, together with the communication of its peripheral branches with other nerves, perhaps explain some of the many types of local and constitutional disturbance which are met with during the process of dentition, *e.g.*, stomatitis, convulsions, bronchitis, vomiting, diarrhœa, skin eruptions, etc.

If these be due to the eruption of teeth, they may be benefited by lancing the gums and so lessening the pressure of the advancing tooth on the nerve filaments of the gums. The roots of the six front temporary teeth are completed about the second year, those of the molars about the fourth year.

Completion of temporary teeth

Separation of temporary teeth

The crypts containing the permanent front teeth are situated on the lingual side of the temporary roots, and at the sixth year of life they have reached such a size that the temporary teeth are forced slightly forward to provide room for them and made to occupy a larger arc. Thus is caused the separation of the temporary teeth often first noticed at that age.

Temporary roots

The roots of the temporary molars are more divergent than those of the permanent. These roots embrace the crowns of the developing bicuspid teeth which succeed them, and the latter may be brought away when extracting temporary molars if too deep a hold is taken.

Extraction of unerupted bicuspids The unerupted bicuspid can easily be extracted after the temporary molar is removed, and this is sometimes done to prevent overcrowding of the permanent teeth where it is evident that such will occur.

Absorption of temporary roots The absorption of the roots of the temporary teeth prior to the crowns being cast off, takes about three years in each tooth, and is completed just before the succeeding tooth is ready to erupt, *e.g.*,

In the central incisor at the 7th year.

In the lateral incisor at the 8th year.

In the canine at the 12th year.

In the first molar at the 10th year.

In the second molar at the 11th year.

Effect of unabsorbed fragments When the permanent teeth erupt, the orifices in their bony crypts are opened much more widely than is necessary to allow the teeth to pass through. Hence if fragments of temporary teeth are unduly retained and press on the erupting permanent teeth, the latter may easily be deflected out of their proper course and irregularly produced.

Irregularities Although many deformities of the dental arches and consequent irregularities of the teeth are hereditary, yet the jaws will yield to slight forces acting for a long time, while they are soft and semi-ossified, and so irregularities may be acquired.

Adenoids Thus, impeded nasal respiration, due to hypertrophy of pharyngeal adenoid tissue, may cause narrowing of the nasal fossæ and a high narrow palate. Further, the "mouth breathing" practised in such cases puts the buccinator muscles on the stretch, and these, pressing on the outer aspects of

Mouth breathing

the teeth, still further narrow and flatten the sides of the arch.

Thumb sucking

Again, the habit of sucking the thumb or toe contracted by many young children causes the upper incisors to be protruded and the lower to be pushed downwards and backwards, producing an unsightly space between their cutting edges, and rendering them almost completely useless.

Premature loss of back teeth

Further, if the back teeth are permanently lost, so that the jaws are not maintained at their proper distance apart, the lower front teeth will bite up too far behind the uppers and gradually force them forward, producing another variety of "superior protrusion."

Superior protrusion

Calcification of permanent teeth

The periods during which the permanent teeth are calcifying are approximately as follows:—

	Crown. Year.		Root. Year.
Central incisors.....	1—6	...	6—10
Lateral incisors.....	1—6	...	6—10
Canine	1—7	...	7—13
Bicuspid I.	2—8	...	8—13
Bicuspid II.	2—9	...	9—13
Molar I.	Birth—5	...	5—9
Molar II.	2—9	...	9—17
Wisdom	Uncertain.		

These periods are important, for they enable us to judge what part of each tooth was forming at any age; and when the gums, tooth germs and jaws pass through a period of malnutrition due to

inflammation or disease, the portion of tooth which was calcifying at that time is likely to show defects.

Hutchinson's teeth

To this cause are due the deformity and notched margins of the central incisors and the mis-shapen crowns of the first molars often seen in congenital

Pitted teeth

syphilis (Hutchinson's teeth), and the pitted or ridged enamel seen in patients who have passed during childhood through some severe febrile disease of which stomatitis formed a symptom, or who had stomatitis caused by the administration of mercury in large quantities for convulsions or other infantile ailment.

Uncompleted teeth

In a fully calcified tooth, the apical foramen is very small; but until completion, the root is widely open at the apex and the soft tissues of the pulp enter in a strand of considerable thickness.

Violence to teeth

Hence rupture of the vessels and nerves at the apical foramen and consequent death of the pulp are less likely to follow a blow on the tooth in children than adults.

Torsion

Further, the operation of twisting a tooth in its socket to rectify malposition can be done without strangling the pulp, only before completion of the

Application of drugs

root. On the other hand, when escharotics, such as arsenic, are placed in a carious cavity to destroy the pulp, there is more danger of leakage of the drug through the apical foramen, with subsequent inflammation in the tooth socket, before than after completion of the root.

If the pulp of a tooth dies before the root is completed, further formation stops and the root remains widely open at the apex. There is the less

motive for the preservation of such roots, as artificial crowns fixed upon them are not often satisfactory.

Pulpitis

The pulp of a tooth is enclosed in a rigid cavity. Hence when the pulp inflames swelling is impossible, pain is severe, and strangulation and death of the pulp a usual result.

Peri-odontitis

Most of the fibres of the alveolo-dental membrane pass downwards and inwards from the socket wall to the cementum. Hence these fibres are slackened by the rising of the tooth in its socket when that membrane is inflamed.

Referred pain

Referred pain is common in connection with the teeth owing to the wide distribution of the fifth nerve.

Thus the pain may be felt in a bicuspid when a molar is the seat of disease; or in the ear from disease of a lower molar or in the eyeball from an upper canine. Pain may be referred from a lower to an upper tooth of the same side, or *vice versa;* but never from one tooth to another on the opposite side of the mouth. The pain in the ear is probably due to the fact that the auriculo-temporal branch of the fifth nerve is in part distributed to the meatus.

Pain in and furring of one side of the tongue have been observed in connection with dental disease. This is probably a reflex effect brought about through the lingual branch of the fifth.

Areas of superficial tenderness

Certain cutaneous areas sometimes show tenderness when the teeth are diseased. According to Dr. Head *(Allbutt's System of Medicine)* these are:—

	Maxillary Teeth.	*Mandibular Teeth.*
Incisors ...	Fronto nasal.	Mental.
Canines ...	Naso labial.	Mental.
Bicuspid I..	Naso labial.	Mental.
Bicuspid II.	Temporal or Maxillary.	Doubtful.
Molar I. ...	Maxillary.	Hyoid.
Molar II. ...	Mandibular.	Hyoid.
Molar III...	Mandibular.	Hyoid or Superior Laryngeal.

The alveoli The outer plates of the alveolar processes are thinner and weaker than the inner plates except in the region of the lower wisdom teeth.

Extraction Hence the rocking movements employed in extracting teeth are mainly in the outward direction.

Alveolar abscess Hence also alveolar abscesses perforate the outer plate more frequently than the inner, and point between the jaw and the cheek. If in the upper jaw they perforate the inner plate they are likely to point upon the palate, and this is commonest in connection with the upper lateral incisor; if in the lower jaw, the pus will be beneath the deep cervical fascia, and is likely to burrow some distance down the neck before it comes to the surface.

Shapes of roots The forms of the beaks of extracting forceps are devised to suit the shapes of the various teeth at their necks. This is best exemplified in the anterior and posterior roots of a lower molar and the single palatine and two buccal roots of an upper molar.

Rotation Rotation is sometimes employed in the removal of a tooth. It can only be practised in single-rooted teeth with approximately conical roots. Such are the upper central incisors and the lower bicuspids.

The roots of the upper lateral incisors and of all the lower incisors are too flattened from side to side and the canine roots are too triangular in section for rotation of them to be advisable. Further, the lower canines are occasionally two rooted.

Direction roots

A tooth should, as far as possible, be removed from its socket in a direction continuous with that of its roots. In this connection the backward slope of the lower molar roots should be remembered, especially in the case of the lower wisdom tooth, where the backward curve is specially marked.

The difficulty of extracting wisdom teeth is greatly diminished by the fact that more often than not their roots are fused into one conical stump.

Antrum

The roots of the second upper bicuspid and the buccal roots of the first two molars are those which most often approach the antrum closely. Hence abscesses connected with them most frequently invade the cavity, and in seizing these roots they may be pushed into the antrum.

Inferior dental nerve

The inferior dental nerve runs in close proximity to the roots of the lower bicuspids and molars, especially the wisdom tooth. It has even been known to groove the root of the last-named, and in such case would be unavoidably injured in extracting the tooth.

The "bite"

Teeth which are thrown out of proper articulation with one another are deprived of most of their usefulness, and it should be remembered that in fractures of the jaws with displacement, this has probably occurred, and if the parts unite in bad

position the masticating power is permanently impaired. Hence simple methods of treating fracture of the lower jaw, such as the four-tailed bandage, are only suitable for cases in which there is no displacement.

THE THORAX.

Sternum The supra-sternal notch is opposite the disc between the second and third dorsal vertebræ, and is about two and a half inches from the spine when the chest is expanded. The depression called the "pit of the stomach" produced by the recession of the xiphoid from the surface, is opposite the ninth dorsal vertebra. The junction of the manubrium and gladiolus is marked by a prominent ridge known as the angle of Ludovici, which corresponds to the second costal cartilage, and is useful in identifying the second rib in a fat subject.

Mamma The nipple in the male lies in the fourth intercostal space. Its position in the female varies with the development of the gland.

The mammary gland usually lies over an area covering the space from the 2nd—7th ribs and from the mid-axillary line to the sternal border, varying according to its size. The variations are due to the development of fat rather than gland tissue. The division of the gland into lobes is very distinct, and the fibrous trabeculæ or "suspensory ligaments" are

Abscess of some strength; hence abscesses in the substance of the mamma are usually multilocular, and the

partitions require breaking down to secure efficient drainage. The ducts radiate from the nipple, and an incision should follow the same direction to avoid as far as possible wounding them. A submammary abscess between the gland and the pectoral fascia is more often unilocular.

Nerves

The breast is supplied by the anterior branches of the second, third, fourth, and fifth intercostal nerves and the lateral branches of the last three of these. The second intercostal gives off the intercosto-humeral nerve to the arm, and communicates with the supra-clavicular branches of the cervical plexus; hence pain originating in the mamma may radiate round the side of the chest and back, down the arm and up the neck. Also in pleurisy there may be pain in the axilla, arm or shoulder (Hilton).

The breast is supplied with blood by branches from the intercostals and internal mammary arteries and by the thoracic branches of the axillary artery.

Lymphatics

The lymphatics of the breast are important in relation to secondary cancerous deposits. The lymphatic vessels form a network beneath the breast and in the pectoral fascia spreading into and between the pectorals in such fashion that it has been recommended that the whole of both pectorals should be removed as a routine operation in cancer. Most of them pass with the long thoracic artery and empty into the anterior axillary glands beneath the pectoralis major, but those from the inner parts of the breast accompany the branches of the intercostal arteries,

to join the sternal glands lying along the internal mammary, the efferent vessels of which enter the anterior mediastinal glands, while a few from the upper border pass to a gland in the groove between the pectoralis major and deltoid, whence vessels pass over the clavicle to enter the glands in the posterior triangle. The mediastinal glands may be affected almost as soon as the axillary. The cervical glands may thus be infected by two routes, the one just mentioned and by extension through the axilla.

Cancer A cancerous growth contracts and draws upon the parts around it. The "retraction of the nipple" produced by dragging upon the lacteal ducts can only be caused by a growth near the centre of the breast. The "'dimpling of the skin" produced by the contraction of the fibrous strands between the skin and the main body of the growth is only seen when the cancer is fairly near the surface. Thus many cancers of the breast show neither of these signs.

Ribs The ribs slope downwards and forwards from the spine to the extent that the anterior ends of the first seven ribs are on a level with the vertebral ends of those three lower in the series.

1st Rib The first rib is so well sheltered beneath the clavicle in front and the muscles of the neck behind that it is rarely fractured.

2nd Rib The second rib cartilage articulates with the sternum at the junction of the manubrium and gladiolus, where a conspicuous ridge or eminence already mentioned is sometimes seen.

The cartilage of the seventh rib articulates at the lower end of the gladiolus, and is the lowest in the series to directly join the sternum.

The eleventh costal cartilage forms the lowest point of the boundary of the thorax. 11th Rib

The third to the seventh ribs inclusive are those most commonly fractured, since, on the one hand, they are fully exposed, and on the other are sufficiently firmly fixed to suffer the full force of the blow to which they cannot yield without breaking, as the more movable lower ribs are able to do. Fracture

The intercostal vessels and nerves lie in a groove behind the lower border of the rib. They are thus protected from injury, but when injured their position renders ligature of the vessel difficult. If difficulty arises in securing the vessels a wire ligature passed round the rib and tightly twisted will always arrest the bleeding. They are best avoided, when tapping or incising the chest, by keeping the instrument close to the lower rib bounding the space. In the posterior parts of the spaces near the spine the intercostal vessels run obliquely, and are not sheltered by the ribs. Hence tapping should not be performed internal to the angles of the ribs. Intercostal vessels

In extensive resections of ribs (Estlander's operation) where the vessels are necessarily cut across, they are often found much lessened in size or almost obliterated by pressure, a result of the disease for which the operation is performed.

Beading of ribs The "beading" or enlargement of the ribs at their junction with the cartilages is a conspicuous sign of rickets.

Pigeon Chest The softness of the chest walls in this condition often causes them to yield to the atmospheric pressure, especially when the effect of this is aided by inspiratory obstruction from enlarged tonsils, bronchitis, etc. Grooves are thus formed, one extending down on each side external to the costal cartilages, the other passing round the lower margin of the chest along the attachment of the diaphragm. The latter groove is partly due to the traction of this muscle. The combined deformity is called "pigeon breast." The eversion of the lower costal margins in rickets is due to distension of the intestines, so common in this disorder.

Pectoralis major The free lower border of the pectoralis major leads in front to the fifth rib. The muscle is covered by the pectoral fascia. Normally the

Pectoral fascia mammary gland slides over this fascia, and adhesion thereto is an important sign in estimating the progress which a malignant growth of the breast has made. Some of the lymphatic vessels form a network in this fascia, which should therefore be removed in amputation of the breast for cancer.

Lungs and pleuræ The boundaries of the lungs and of the parietal pleura may be taken as identical, except along the lower margin of the thorax.

Apices The dome-like arch of the pleura, covered by the cervical fascia, may rise as high as one and a half inches above the level of the clavicle into the neck.

Its presence must be borne in mind in operations about the root of the neck, such as ligature of the great vessels and extirpation of glands, since injury to it is likely to be followed by a fatal pleurisy.

Anterior borders

From the apices the anterior borders of the lungs approach each other obliquely, passing behind the sterno-clavicular joints and manubrium sterni, and meeting in the middle line opposite the second costal cartilages. The anterior border of the right lung then continues downwards in the middle line to the sixth costal cartilage; that of the left lung passes down in the middle line as far as the fourth cartilage, where it bends outwards along that cartilage; thence across the fourth and fifth interspaces to reach the sixth rib, a little external to the para-sternal line.

Lower borders

The lower borders of the lungs take a curved course from the sixth chondro-sternal joint round the chest to the level of the tenth dorsal spine posteriorly. The lower border of the right lung starts from the middle line, but that of the left three inches from it. The lungs extend to the lower border of the sixth rib in the nipple line, to the eighth in the mid-axillary and to the tenth in the scapular line, the left lung extending throughout to a slightly lower level than the right.

Great fissure of lungs

The great fissure in each lung extends from the second dorsal spine to the sixth rib in the nipple line.

Smaller fissure of right lung

The smaller fissure of the right lung extends from the centre of the great fissure to the fourth chondro-sternal articulation.

The anterior borders of the lungs overlap the heart, except where the left lung is notched.

The lower borders of the lungs descend one and a half inches in inspiration.

The pleura along its lower margin reaches at each point one rib and one interspace lower than the lung. Behind, it reaches the level of the eleventh dorsal spine and the lower margin of the twelfth rib. The sac may sometimes extend lower still, and might be wounded in operations about the loin, such as nephrectomy.

Empyema The layers are here quite close together, and if an attempt were made to open an empyema at quite the bottom of the sac they would probably be found fused together by adhesions, or the cavity obliterated by masses of lymph. Hence the eighth space in the posterior scapular or the seventh in the axillary line is usually chosen. On the other hand, foreign bodies loose in the pleural cavity could be conveniently extracted through the eleventh space.

An empyema left without incision would probably point in front in the inter-chondral spaces, since the chest wall is here weak through deficiency of the inter-costal muscles and the thinness of the pectoralis major.

Heart The heart corresponds behind to the sixth, seventh and eighth dorsal vertebræ. Its relation to the front wall of the chest are as follows:—

The apex is in the fifth inter-space, three and a half inches from the middle line.

The left border convex outwards, passes from the

apex to the upper edge of the third left cartilage, one and a half inches from the sternum. This border is three inches from the sternum at the fourth cartilage.

The lower border passes from the apex, across the sterno-xiphoid joint to the upper border of the seventh right chondro-sternal joint.

The right border passes upwards from the last-named point to the upper edge of the third right cartilage, half an inch from the sternum. This border is convex outwards, and reaches a maximum distance of one inch from the sternum.

The base of the heart corresponds to a line across the sternum at the level of the upper borders of the third cartilages joining the upper ends of the right and left borders.

The left border is formed by the left ventricle, the lower by the right, and the right border by the right auricle.

The portion of the heart uncovered by lung may be represented by a circle of one inch radius, described round a point midway between the left nipple and the lower end of the gladiolus (Latham).

Ascending aorta

The *ascending aorta* which is two inches long lies at its commencement behind the left half of the sternum on a level with the lower border of the third costal cartilage, and from thence passes upwards and to the right as far as the attachment of the second right costal cartilage to the sternum.

Arch of the aorta

The aortic arch extends from the right border of the sternum at the level of the second costal cartilage to the left side of the lower border of the

fourth dorsal vertebra, where it becomes continuous with the descending thoracic aorta. In this course the vessel curves round the trachea, its upper border, as it crosses the median plane, being about one inch below the inter-clavicular notch of the manubrium.

Innominate The *innominate* artery extends from the top of the arch, just on the right of the middle line, to the upper edge of the right sterno-clavicular joint.

Left common carotid The *intra-thoracic portion of the left common carotid* extends from the top of the arch just on the left of the innominate, to the upper edge of the left sterno-clavicular joint.

Left subclavian The *intra-thoracic portion of the left subclavian* is indicated by a line from the aortic arch to the clavicle along the left border of the sternum.

Left innominate vein The *left innominate vein* passes just below the sternal notch from the inner end of the left clavicle to the junction of the first right costal cartilage with the sternum. It lies between the manubrium sterni and the innominate and left carotid arteries. It is in danger of perforation by a long and ill-fitting tracheotomy tube.

Right innominate vein The *right innominate vein* descends from the right sterno-clavicular joint to meet the left and form the

Superior vena cava *Superior vena cava*, which descends along the right border of the sternum from the first to the third cartilage.

Pulmonary artery The *pulmonary artery* extends from the upper border of the third left cartilage at its sternal end and bifurcates at the upper border of the second.

The *internal mammary arteries* pass downwards in front of the pleura, behind the cartilages of the ribs, about half an inch from the sternum. These arteries can be secured in any of the five highest spaces, but the vessels bifurcate in the sixth spaces into musculo-phrenic and superior epigastric arteries. **Internal mammary**

The surface extent of the various organs now described is of importance in estimating the effect of penetrating wounds of the thorax at various sites and levels.

The pericardium can be tapped through the fourth or fifth left interspace, keeping sufficiently far from the sternum to avoid the internal mammary artery. **Tapping pericardium**

A trocar has been passed into the right auricle through the fourth or fifth right interspace near the sternum to relieve intense engorgement of the right side of the heart. **Right auricle**

It has been proposed to tie the innominate artery through a hole trephined in the manubrium sterni over the vessel.

The trachea, four and a half inches long, bifurcates opposite the disc between the fourth and fifth dorsal vertebræ. In the thorax it is separated from the spine by the œsophagus. It lies between the two pleural cavities, is crossed transversely at its lower end by the arch of the aorta, while the innominate and left common carotid arteries pass obliquely upwards and to the right and left sides of it respectively. It is also crossed by the left innominate vein, and the remains of the thymus **Trachea**

gland and the deep cardiac plexus are in front of it. The left recurrent laryngeal nerve is in contact with the trachea after it has wound round the aortic arch.

Bronchi The right bronchus is wider, shorter and more horizontal than the left. The ridge inside the trachea dividing the two bronchial orifices is to the left of the middle line. Hence foreign bodies are said to more usually fall into the right bronchus.

Mediastinal glands Many lymphatic glands occupy the mediastinal cavities, especially about the concavity of the aortic arch and bifurcation of the trachea. These may become enlarged by secondary cancerous deposits or be the seat of lympho-sarcomata or the enlargements of Hodgkin's disease. Such tumours may press upon and obstruct the trachea or bronchi or implicate the recurrent laryngeal nerve producing laryngeal paralysis.

Abscess, glandular or spinal, in the posterior mediastinum may be reached without much difficulty by resection of a rib behind the angle.

Trunk of aorta The aorta descends on the left of the thoracic spine, gradually reaching the middle line below.

Oesophagus The gullet is at first to the right of the vessel, but crosses in front of it and reaches its left side before it pierces the diaphragm. Bodies impacted in the œsophagus may slough into the trachea or one of the great vessels.

Thoracic duct The thoracic duct in the thorax lies between the œsophagus and the spine.

THE BACK.

The back presents a median groove with the line of spinous processes showing cervical and lumbar concavities and a dorsal convexity.

Spinous processes

The spinous processes in the middle of the cervical series are not easily made out. The seventh cervical spine is prominent and the spine of the axis fairly palpable. Distinct intervals, through which punctured wounds of the cord may occur, exist between the laminæ and the cervical vertebræ, especially between the occiput and atlas, and between the atlas and axis.

The thoracic spines, oblique at first, more nearly approach the vertical in direction as the centre of the series is reached and then become more and more horizontal, so that the twelfth dorsal spine is almost exactly so. This is of importance, for by reason of it the dorsal spines are not at the same height as their corresponding ribs or nerves, except in the case of the eleventh and twelfth vertebræ, which more nearly approach that level.

The laminæ in the dorsal region are very oblique, and overlap; hence punctured wounds of the cord are uncommon in this region.

The second lumbar spine marks the level of the termination of the cord, and the fourth the bifurcation of the aorta.

The movements possible to the spine are most extensive in the lumbar and cervical regions, and most restricted in the dorsal.

Lateral curvature

When the pelvis is oblique as a result of inequality in the length of the legs, the lumbar spine assumes a lateral curve convex towards the depressed side of the pelvis and a compensatory curve in the opposite direction appears in the dorsal region. These lateral curves may also be due to weakening of the ligaments and muscles which brace up the spine. Owing to the nature of the articulating surfaces, lateral curvature of any extent is accompanied by a partial rotation of the vertebræ on a vertical axis, so that their bodies incline towards the side of the convexity and the spines towards the concavity, thus tending to mask the amount of curvature.

Vertical rotation of vertebræ

Distortion of ribs

Following on this are deformities of the ribs. The ribs on the side of the convexity become more acutely bent at their angles and straightened out anteriorly, while those on the opposite side are partially straightened at their angles and abnormally curved anteriorly. The scapula cannot adapt itself closely to the ribs, and often projects in a striking manner beneath the skin ("growing out" of the shoulder). This projection of the scapula is still more marked in cases of paralysis of the serratus magnus, many of which used to be described as dislocations of the scapula over the latissimus dorsi muscle.

Displacement of scapula

Intervertebral discs

The efficacy of the inter-vertebral discs in deadening the effect of longitudinal pressure should be noted.

Dislocation

The shape and direction of the surfaces of the articulating processes render dislocation of the

spine without fracture impossible in the dorsal region, extremely rare in the cervical, and still rarer in the lumbar.

Lordosis, or an exaggeration of the normal lumbar curve is produced as a compensatory measure by anything which causes tilting forward of the pelvis in the erect posture. Such causes are hip disease, congenital dislocation of the hips, rickets, etc. Rigidity with flexion of the upper part of the spine will have a similar effect. **Lordosis**

Kyphosis and exaggeration of the normal dorsal curve may be produced by any cause which weakens the posterior spinal muscles, *e.g.*, old age, debility, rickets, caries, etc. It is obvious that the tendency of the divisions of the erector spinæ must be to straighten the dorsal curve, which by the body weight becomes increased when they act deficiently. **Kyphosis**

Since the spinal cord terminates opposite the lower border of the first lumbar vertebra it is evident that the nerves must arise from the cord at a higher level than that at which they leave the spinal canal. The extent of this difference increases as we pass down the series. Also the points of origin of the nerves become more crowded together as the end of the cord is reached. **Nerves in canal**

The eight cervical nerves arise from the cord between the occiput and the sixth spine. **Relation of nerve origins to spinous processes**

The upper six dorsal nerves between the sixth cervical and the fourth dorsal spines.

The lower six dorsal nerves between the fourth dorsal and the 11th dorsal spines.

The five lumbar nerves arise between the 11th and twelfth dorsal spines.

The five sacral nerves opposite the twelfth dorsal and first lumbar spine.

These points are of importance surgically, since a lesion can be localised with respect to the cord by the extent of the paralysis, anæsthesia, etc., but in dealing with it by operation it is necessary to know the corresponding external landmark.

Spinal dura mater

The dura mater of the spinal canal forms a loose sheath for the cord, not adherent to the vertebræ, but continuous with that lining the skull around the margins of the foramen magnum. This sheath descends as far as the third piece of the sacrum. A penetrating wound at this level may therefore open the subdural space, whereas a direct wound of the cord cannot occur below the first lumbar vertebra.

Spina bifida

The neural arches may be congenitally deficient in any part of the spinal column, and through the gap the contents of the canal may protrude, forming one or other of the varieties of "spina bifida."

ABDOMEN.

Umbilicus

The umbilicus is a little below the centre of the linea alba or median line drawn from the xiphoid. It lies above the mid point when the lower segment of the abdominal wall is distended. It is on a level with the disc between the third and fourth lumbar

vertebræ and the third lumbar spine, and is about three-quarters of an inch above a line drawn between the highest points of the iliac crests, and the same distance above and to the right of the bifurcation of the aorta opposite the body of the fourth lumbar vertebra. Congenital umbilical hernia protrudes at the navel, acquired hernia either above or below it. A line drawn from the bifurcation of the aorta on either side to a point midway between the anterior superior spine of the ilium and the symphysis pubis will mark in its upper third the course of the common iliac artery and in its lower two-thirds the external iliac.

Iliac arteries

The position of the bifurcation of the aorta is the point where pressure is applied to arrest circulation in the vessel.

Linea semilunaris

The linea semilunaris, indicating the outer edge of the rectus is slightly convex outwards, lies about three inches from the middle line opposite the umbilicus and extends from the spine of the pubes to the tip of the ninth costal cartilage. The rectus is usually crossed by three tendinous intersections, one opposite the umbilicus and two between that point and the ensiform cartilage. Contraction of portions of the muscle between these intersections may cause one form of "phantom tumour."

The rectus muscle

Phantom tumour

Arteries of abdominal wall

The arteries of chief importance in the abdominal wall are (1) the superior epigastric branch of the internal mammary occupying the upper part of the sheath of the rectus, behind the muscle.

(2) The deep epigastric artery running in a line from the point at which the iliac artery reaches

Poupart's ligament to the umbilicus. The vessel passes to the inner side of the internal abdominal ring lying at first beneath the fascia transversalis; subsequently it pierces that fascia, and enters the sheath of the rectus by passing in front of the semilunar fold of Douglas, to terminate by anastomosing with the superior epigastric. It is apt to be wounded in operations if the lower end of an iliac incision is carried too far inwards.

(3) The deep circumflex iliac starts at the same point as the last-mentioned artery, and runs behind Poupart's ligament to the anterior superior iliac spine, and thence along the crest of the ilium between the internal oblique and transversalis to anastomose with the ilio-lumbar and gluteal arteries. A large ascending branch passes upwards opposite the anterior superior spine between the internal oblique and transversalis muscles, to anastomose with the lumbar and intercostal arteries.

The superficial arteries, epigastric, circumflex iliac and external pudic are not of great importance. The last-mentioned is usually divided in the first incision over an inguinal hernia.

Veins

The superficial veins of the abdominal wall may be rendered prominent as collateral channels in obstruction of the inferior vena cava or by simple varicosity. The epigastric, lumbar, and internal mammary veins are found to anastomose, and a lateral trunk stretches from the axillary vein to the femoral. The superficial veins round the umbilicus communicate with the portal vein by small branches

passing along the round ligament, and are hence found enlarged in diseases of the liver obstructing the portal circulation. This fact supports the value of the operation for procuring adhesions between the abdominal wall and the liver or omentum in cases of ascites.

Nerves of abdominal wall

The abdominal wall is supplied by the lower seven dorsal and two highest lumbar nerves. The tenth dorsal nerve corresponds to the umbilical region. The abdominal muscles are supplied by the same nerves which also supply the lower intercostal muscles and communicate with the lower seven dorsal ganglia of the sympathetic, from which the splanchnic nerves supplying the abdominal viscera arise. The intimate connections existing between the nerve supply of the abdominal organs, muscles and skin serve to explain the surface pain in visceral lesions and the reflex contraction of the muscles upon the application of cold or in painful conditions of the skin or underlying organs, such as burns or peritonitis respectively. The parietal peritoneum is sensible to violence of any sort, while the visceral may be wounded without any feeling of pain, as in opening the intestine in the second stage of a colotomy. The muscular contraction is an attempt to minimise the effects of the lesion by bringing about rest of the parts. Disease of the spine affecting the nerve trunks near their origin may cause pain which will be referred by the brain to the area of distribution of the nerve upon the front of the abdomen, or may give rise to the sense of a painful zone or constricting band encircling

the body, or to an annular eruption of herpes. So, too, diaphragmatic pleurisy or hepatitis may cause pain in the shoulder by transference from the phrenic to the superficial cervical nerves. James Mackenzie and others have shown that so-called visceral pain is a question of hyperæsthesia in the skin and underlying structures of the abdominal wall, and that though the viscus may be itself insensitive the site of the lesion may be inferred from the position of the hyperæsthesia in some cases, *e.g.*, gastric ulcer.

Malformations

Umbilical hernia

The chief malformations of the anterior abdominal wall are the defective closure of the umbilicus, giving rise to congenital hernia in that region, or to the extensive protrusions of the viscera (hepatomphalos, etc.), which are usually incompatible with life, also to the condition known as extroversion of the bladder. Here the abdominal wall below the umbilicus in the middle line and the anterior wall of the bladder are wanting, while the posterior vesical wall is continuous with that of the abdomen round the margins of the defect; the lining of the bladder and orifices of the ureters are exposed in front, the dorsal parts of the penis and roof of the urethra are commonly undeveloped, and an interval of varying extent separates the pubic bones in the middle line. In these cases the umbilicus itself may be absent, or rather indistinguishable.

Ectopia vesicæ

Inguinal canal external ring

The external abdominal ring is the slit varying in size in different subjects, between the portions of the external oblique aponeurosis, which are

inserted into the spine and symphysis pubis. It can best be made out by invaginating the scrotum upon the finger till the spine of the pubes is felt, and then directing the finger backwards as if to point it towards the sacrum. In the female the spine of the pubes can be conveniently identified by following up the inner tendinous border of the adductor longus.

Internal abdominal ring

The inguinal canal which transmits the spermatic cord, extends obliquely through the abdominal wall, stretching between the internal and the external abdominal ring. Its length is about two inches, and its direction is mainly inwards, with a slight inclination downwards and forwards. The internal abdominal ring is situated about half an inch above the centre of Poupart's ligament. The canal is triangular in section, the base or floor being formed by the grooved surface of Poupart's ligament and in part by Gimbernat's ligament; the anterior wall, by the external oblique, and in the outer part by the internal oblique; the posterior wall, by the fascia transversalis externally, and the conjoined tendon with the triangular fascia internally. The apex or roof is formed by the meeting of the anterior and posterior walls and by the lower margin of the transversalis and internal oblique muscles. Two points require special notice in considering these boundaries—the first is that the lower margin of the transversalis lies above the level of the internal ring, and therefore that muscle can have no share in the formation of the walls of the canal; and the second, that the

internal oblique assists in forming both the anterior and posterior walls, its lower margin arching over the spermatic cord, so that while externally the muscle lies in front of that structure, internally, by means of the conjoined tendon, it is placed behind it.

Hernia

An oblique inguinal hernia enters the canal at the internal ring, and passes down the whole length of it, receiving in succession the following coverings:—

1. Peritoneum.
2. Subperitoneal fat.
3. Infundibuliform or internal spermatic fascia (derived from the transversalis fascia).
4. Cremasteric fascia from the lower edge of the internal oblique.
5. Inter-columnar or external spermatic fascia (derived from the deep fascia of the abdomen adherent round the external abdominal ring and the inter-columnar fibres of the external oblique aponeurosis).
6. Superficial fascia.
7. Skin.

These separate layers are not always demonstrable in actual cases.

Pouches of peritoneum

Three peritoneal pouches are formed on the internal surface of the abdominal wall. The *outer*, most distinct, corresponding to the internal abdominal ring, just outside the deep epigastric artery, is the site of protrusion of an "indirect" or "oblique" inguinal hernia, called also "external" from its relation to that vessel.

Oblique hernia

The *inner* pouch, between the obliterated hypogastric artery and the urachus, is the site of protrusion of a "direct" hernia, also named "internal" from its position with respect to the deep epigastric artery. This hernia enters the inguinal canal near its lower end, and receives a special sheath from the conjoined tendon in place of the cremasteric fascia. Also its covering is derived from the common transversalis fascia behind the conjoined tendon, and not from the special "infundibuliform" portion prolonged upon the spermatic cord. The *middle* pouch is the smallest, and present only when the course of the epigastric artery does not coincide with that of the obliterated hypogastric, as it usually does. The latter vessel then subdivides "Hesselbach's triangle," *i.e.*, the space between the epigastric artery, Poupart's ligament and the outer border of the rectus. A hernia entering the canal through this middle pouch would be "direct" in the sense of being "internal" to the deep epigastric, but its coverings would be those of an oblique hernia, since it would be external to the conjoined tendon and would receive a sheath from the internal oblique. Its third covering would not be derived from the infundibuliform fascia, however, as in oblique hernia, but from the transversalis fascia forming the posterior boundary of the outer part of the canal. Direct hernia

The length and the obliquity of the inguinal canal are produced at a late period of development. When the testicle descends the internal and external openings are opposite each other. The testicle may

fail to reach the scrotum and form a tumour in the inguinal canal simulating hernia. The canal quickly loses its obliquity in cases of hernia.

Funicular process

As well as the spermatic cord and vessels, the inguinal canal contains the remains of the funicular process of peritoneum which precedes the testicle in its descent and forms the tunica vaginalis. If this process remains patent throughout, the cavity of the tunica vaginalis communicates with the peritoneal cavity by a passage down which a hernia can descend *(congenital hernia)*. When the process is closed only at the internal ring the cavity of the tunica vaginalis extends up the canal, and the septum at the upper end may be invaginated into the lower part of the process, or the hernia may descend behind the funicular tube in a special peritoneal pouch of its own. The former of these varieties is an "*encysted*," the latter an "*infantile*" hernia.

Congenital hernia

Infantile hernia

Funicular hernia

When the peritoneal process is patent as far as the upper end of the testicle, but is there shut off from the tunica vaginalis, a hernia descending into it is called a *hernia into the funicular process*. The incision to relieve the strangulation in inguinal hernia is made directly upwards to avoid the deep epigastric artery running internal to the neck of the sac.

Genito-crural nerve

The genital branch of the genito-crural nerve lies upon the surface of the spermatic cord or the round ligament, as the case may be, and is to be avoided when the canal is opened up in Alexander's operation for shortening the round ligaments of

the uterus since pain may follow if it be included in sutures applied to the ligaments.

Since the genito-crural nerve arises from the second lumbar cord and supplies the cremaster muscle, pressure upon it by the enlarged veins of a varicocele may well explain the back pains felt by some of the sufferers from this trouble, and also possibly the extreme slackness of the cremaster may be due to interference with its innervation. Other explanations of these conditions may, of course, be readily found, but it is possible that the above may be contributory factors.

Arteries of spermatic cord

When the spermatic cord is divided in excision of the testicle the spermatic and cremasteric arteries and the artery of the vas deferens usually require ligature.

Canal of Nuck

If the funicular process is unobliterated in the female a small diverticulum from the peritoneum (canal of Nuck) accompanies the round ligament in the inguinal canal. Into this a hernia may take place, or by distension of it a hydrocele be formed. Though both extremities of the process be obliterated segments of it may remain patent, and these suffering gradual distension may form "encysted hydroceles of the cord" in the male, or of the canal of Nuck in the female.

Hernia and hydrocele

Encysted hydroceles

Umbilical hernia congenital

A child may be born with a "congenital" hernia at the umbilicus, or bowel may protrude beneath the skin before the fibrous ring has closed; the latter would be an "infantile" umbilical hernia. An "acquired" hernia of this region may protrude at the site of the primitive opening by stretching the

Infantile

Acquired

umbilical cicatrix or through an adjacent part of the linea alba. Such a hernia is covered by:

1. Peritoneum.
2. Extra-peritoneal fat.
3. Transversalis fascia.
4. Fibrous covering from scar tissue or linea alba.
5. Superficial fascia.
6. Skin.

Triangle of Petit

The middle point of the iliac crest represents the interval between the borders of the external oblique and latissimus dorsi (triangle of Petit), through which a hernia may protrude or a lumbar abscess point. It also marks the outer border of the quadratus lumborum at its origin from the crest. The border of the muscle slopes upwards and inwards, being about two inches nearer the middle line at its insertion into the last rib. The erector spinæ covers the inner two-thirds of the quadratus and the internal oblique the rest.

Fascia lumborum

The fascia lumborum or vertebral aponeurosis of the transversalis muscle splits into three layers along the outer border of the quadratus lumborum. The anterior layer is attached to the last rib, to the crest of the ilium and to the bodies of the lumbar vertebræ in front of the roots of the transverse processes. The middle layer is attached to the tips of the transverse processes, and the posterior to the tips of the spinous processes and inter-spinous ligaments. The anterior and middle layers enclose the quadratus lumborum, and the middle and posterior layers the erector spinæ. The closed

fascial compartment containing the quadratus lumborum is pierced by the last dorsal artery and nerve and by the ilio-hypogastric and ilio-inguinal nerves, which lie anterior to the muscle beneath the fascia. These nerves may be left exposed in renal or other operative wounds, and sometimes cause much pain when a suture or a drainage tube presses upon them.

Peri-nephritic abscess

The pus of a peri-nephritic abscess may burrow into this compartment from the front along these nerves and then pierce the quadratus and two posterior layers of the fascia with the internal oblique muscle, and point in the triangular interval between the external oblique and latissimus dorsi above the crest of the ilium.

Psoas muscle

The psoas muscle arises from the sides of the bodies and the transverse processes of all the lumbar vertebræ and from the body of the twelfth dorsal. Its upper end thus projects above the diaphragm into the cavity of the thorax, and is arched over by the ligamentum arcuatum internum.

Psoas fascia

The sheath covering the psoas is derived from the transversalis fascia, and is continuous with that covering the iliacus muscle. It is attached above to the internal arcuate ligament, internally to the spine in front of the origin of the psoas, to the front of the sacrum and along the brim of the pelvis. Externally it is attached along the outer border of the psoas to the anterior layer of the lumbar fascia, thence along the crest of the ilium and Poupart's ligament to the point at which the vessels pass into the thigh. Here the fascia

covering the muscle passes beneath the vessels, forming the posterior layer of the femoral sheath and becoming continuous with the pubic portion of the fascia lata of the thigh. It will thus be seen that the ilio-psoas muscle is covered by a fascial sheath which has no outlets for pus confined beneath it except the passage into the thigh beneath the femoral vessels or that into the thorax beneath the arcuate ligament. But large collections of slowly forming pus are influenced largely by gravity, and so, as a rule, a psoas or iliac abscess points in the upper part of the thigh just outside the femoral vessels or passing behind them, and following the muscle may point in the buttock at the insertion of the ilio-psoas into the small trochanter a little lower down. Often, however, on reaching the lowest part of the iliac fossa, the pus does not progress further downwards along the femoral vessels, but pierces its confining sheath and points above Poupart's ligament external to the vessels. The matter from spinal caries usually enters the substance of the psoas muscle between its attachments to the bodies and transverse processes of the vertebræ. The principal trunks of the lumbar plexus lie in this interval, and the pus readily tracks along these and traverses or destroys the belly of the muscle. The matter from dorsal caries, after reaching the lowest part of the thorax, can burrow into the psoas through the digitation which presents above the diaphragm, and pass down beneath the arcuate ligament. Often these abscesses are not limited anatomically in the manner described, but burrow

Abscess

in various directions. Thus, after penetrating the sacro-sciatic or obturator foramina the abscess may point on the buttock, or the pus may burrow along the inguinal canal or may follow the femoral or profunda vessels along the inter-muscular planes of the thigh and leg. In opening a psoas abscess from behind, the incision is made along the outer border of the erector spinæ, the posterior layer of the lumbar fascia is divided, the erector spinæ drawn towards the spine, the middle layer of fascia divided close to the transverse processes, avoiding the intervals between them where the arteries run, the quadratus lumborum and anterior layer of the fascia are divided, and the abscess cavity thus exposed.

THE VISCERA.

Spleen

The outer surface of the spleen is in contact with the diaphragm under the ninth, tenth and eleventh ribs on the left side, and its long axis is parallel to them. Its upper limit is on a level with the ninth dorsal spine, and its lower with the first lumbar. Its upper extremity reaches to about one and a half inches from the middle line behind, and its lower comes as far forwards as the mid-axillary line. The antero-internal surface is in contact with the fundus of the stomach, the postero-internal with the left kidney, and between the two the tail of the pancreas touches the organ. The spleen cannot be palpated unless it is enlarged, when it extends downwards and inwards towards the umbilicus.

Enlargement

The enlarged spleen of chronic malaria is

susceptible to rupture on application of slight violence.

Vessels The splenic vessels enter the inner border of the organ, and the splenic artery gives off the left gastro-epiploic along the greater curvature of the stomach.

Since this vessel anastomoses with the right gastro-epiploic artery it is not sufficient to secure the main splenic vessels in excising the organ, but all the branches in the gastro-splenic omentum must be tied, preferably by ligaturing the whole pedicle.

The splenic vein is very thin walled, and often receives large tributaries through the diaphragm; these are a source of great danger in splenectomy.

Diaphragm The central tendon of the diaphragm has a mean position at the level of the seventh chondro-sternal joint. The right vault rises to the upper border of the fifth rib, in the nipple line, while the left has a slightly lower level.

Liver The upper surface of the liver corresponds to the diaphragm, but the left lobe only extends one and a half inches to the left of the sternum. The lower border reaches a quarter of an inch below the right costal margin, and crosses the sub-costal angle obliquely from the ninth right to the eighth left cartilage, about a hand's breadth below the sterno-xiphoid articulation (Godlee). The plane of the upper surface of the liver cuts the seventh rib in the axillary line and the ninth in the scapular. The organ rests against the posterior thoracic wall with the diaphragm intervening, below the margin of the

right lung, over an area opposite the tenth and eleventh dorsal vertebræ, or tenth dorsal spine. Mr. Hilton, in mentioning the distribution of the phrenic nerve upon the abdominal surface of the diaphragm, points out how it is in this way protected from injurious pressure by the expanding lungs, and that the tendency of gravitation is to carry the abdominal viscera away from the nerve. This suggests also an explanation of the relief obtained by sitting upright in some cases of dyspnœa, a relief often attributed to diminution of direct pressure upon lungs and heart through the diaphragm; it also suggests the possibility of a self-acting safety apparatus in too violent respiratory efforts; if the diaphragm descends beyond a certain point in inspiration the phrenic nerve would be compressed against the liver and its action checked.

Gall Bladder

The fundus of the gall bladder lies behind the ninth right costal cartilage, and if distended usually projects downwards and inwards towards the umbilicus. A tender spot in the line from the 9th rib to the umbilicus is suggestive of gall-bladder disease (Robson). It is in relation with the hepatic flexure of the colon, and touches the first part of the duodenum. A gall-stone may ulcerate from the viscus into either of these portions of the intestine, or an anastomosis may be effected by operation.

Kidneys

The kidneys lie along the sides of the last dorsal and first three lumbar vertebræ. The right organ is three-quarters of an inch lower than the left, and its inferior end reaches to within half an inch of

the level of the umbilicus. Two-thirds of the kidney lie internal, and one-third external to a line drawn vertically upwards from the middle of Poupart's ligament. About one-third of each kidney lies above the last rib. Posteriorly, the upper end of the kidneys are in the lowest inter-costal spaces, and each organ corresponds to a rectangle whose horizontal sides are at the level of the lower borders of the eleventh dorsal and third lumbar spines, and whose vertical sides are one inch and three and three-quarter inches from the middle line of the back (Morris).

It is to be remembered in operations about the kidney that its relation to the twelfth rib varies considerably with different forms of chest and degrees of muscular development, as well as with the size of the liver and the mobility of the kidney itself. In inspiration even unenlarged kidneys move freely downwards, but this can seldom be detected in an organ of normal size.

True floating kidney

The kidneys are in direct contact with the peritoneum only over the anterior surfaces of their upper and lower ends. Elsewhere other organs intervene between the serous membrane and the kidney. Thus the right kidney is covered in front by the ascending colon and second part of the duodenum, and the left by the spleen, pancreas and descending colon. Hence a renal abscess rarely bursts into the peritoneal cavity, but burrows in the retro-peritoneal cellular tissue, pointing as a lumbar abscess or opening into the colon or passing down behind the rectum into the pelvis. The

kidneys may have abnormal relations to the peritoneum and the other organs, and may be completely invested with a serous covering and provided with a mesentery which allows the organ preternatural mobility.

The kidney is reached in the loin by oblique incision, parallel to the last rib, of an extent and at a level which will easily be inferred from the rectangular area given above. The kidney rests upon the psoas and quadratus lumborum muscles and the diaphragm to the level of the upper border of the eleventh rib on the left side and the lower border on the right. The last dorsal, ilio-hypogastric, and ilio-inguinal nerves and the anterior divisions of the first two lumbar arteries all pass between the kidney and the quadratus lumborum muscle. The transverse processes of the first and second lumbar vertebræ extend outwards beyond the inner margin of the kidney, and their presence should be remembered when sounding the organ for stone, since impact of the needle upon them might cause a false impression as to the presence of a renal calculus.

"Horseshoe" kidney

In approaching the kidney from the front the colon is turned outwards and the peritoneum divided internal to it. The condition of "horseshoe" kidney and the occasional absence of one organ or its malposition in the pelvis should always be remembered.

Malposition

The ureter

The ureter passes downwards, resting on the psoas muscle, and enters the pelvis by crossing either the common or the external iliac vessels. It

then turns forwards in the posterior false ligaments of the bladder to reach that organ, being crossed internally by the vas deferens. In the female the ureter runs in the fold of Douglas and passes beneath the broad ligament in close relationship to the cervix of the uterus lying about half an inch external to the cervix. In its further course it rests against the side wall of the vagina, finally passing between the anterior wall and the bladder to enter the latter organ. Its proximity to the cervix must be remembered in operations about that region. The ureter lies immediately beneath the posterior parietal peritoneum, covered by the intestines and omentum and crossed from within outwards by the spermatic vessels. It adheres to the peritoneum more closely than to the abdominal wall, and may be inadvertently turned forwards with that membrane when it is being searched for in operations.

Stomach

The position of any portion of the stomach except the cardiac orifice varies greatly with the degree of distension; but the mean boundaries are:

The *cardiac orifice* lies behind the seventh left costal cartilage, one inch from the sternum.

The *pylorus* lies behind the sternal end of the eighth right cartilage.

The general axis of the fundus of the cardiac end rises higher than the level of the cardiac orifice, namely, as high as the sixth chondro-sternal articulation, behind and slightly above the apex of the heart (Treves). Obviously the stomach can be displaced downwards by a left pleural effusion, or,

on the other hand, distension of the stomach may impede the respiratory movements or the action of the heart. The anterior surface of the stomach as far as the left side of the cardiac orifice is overlapped by the left lobe of the liver. The transverse colon runs along the lower border. The organ itself overlies the spleen in part, the left kidney and supra-renal capsule, the pancreas and the third part of the duodenum.

The stomach is in direct contact with the anterior abdominal wall in the sub-costal angle between the margin of the liver and the eighth and ninth left cartilages. The organ is approached through an incision near this part of the thoracic margin in the operation of gastrostomy for stricture of the gullet, or gastrotomy for extraction of a foreign body or dilatation of the orifices. The centre of the incision should be about three-quarters of an inch below the edge of the liver at the point of operation. **Gastrostomy**

The pancreas lies upon the first and second lumbar vertebræ at a level three inches above the umbilicus. Its head is enclosed in the curve formed by the second and third parts of the duodenum, and the body of the gland lies along the upper border of the third part. The pancreas rests upon the vena cava, aorta, superior mesenteric artery, mesenteric veins, the commencement of the portal vein, crura of diaphragm, spine and left kidney, and touches the spleen. It is covered by the stomach, the lesser peritoneal sac intervening. **Pancreas**

The head of the pancreas is often involved in pyloric cancer or inflammatory effusion, and may

thus compress the common bile duct which lies behind it, causing jaundice.

Tumours and cysts of the pancreas readily receive communicated pulsation from the aorta, and may simulate aneurism.

A normal-sized pancreas may occasionally be felt by palpation in cases of great emaciation.

Duodenum The first part of the duodenum is in the right hypochondrium, touching the gall-bladder and liver. The second part descends in front of the right kidney and in contact with the head of the pancreas as low as the third lumbar vertebra. The third part crosses the spine obliquely from the right side of the third to the left side of the second lumbar vertebra. The first portion only is completely covered by peritoneum and movable.

Small intestine The rest of the small intestine is too movable for precise localisation of parts. The coils lie below the transverse colon, and are covered by the great omentum.

Meckel's diverticulum Meckel's diverticulum, when present, is usually about two feet from the termination of the ileum. It may enter a hernia, "Littre's hernia," or may strangulate the bowel by twisting round a loop of gut in various ways or by contracting adhesions, or may form one variety of umbilical fistula.

Omentum Regarding the omentum, it need only be mentioned that this membrane, tightly nipped in the neck of a hernial sac, may produce all the symptoms of strangulated bowel; that internal strangulation may take place by reason of the bowel slipping through apertures in the omentum; that

the omentum may contribute to the formation of constricting bands, and that tumours and cysts of the omentum have to be diagnosed from those affecting the bowel or other organs.

Mesentery

The mesentery of the small intestine is attached to the posterior abdominal wall along a line from the left side of the second lumbar vertebra to the right iliac fossa. Its normal length, from the parietal attachment to the gut, nowhere exceeding ten inches, will not allow a loop of bowel to be drawn through the inguinal or crural canals. Hence the mesentery must be elongated in all cases of inguinal or femoral hernia. Apertures may exist in the mesentery through which intestine may pass and be strangulated.

Cæcum

The cæcum and the appendix have a mean position in the right iliac fossa, but are usually completely invested with peritoneum, and very movable, capable even of entering an external hernia. The lowest point of the convexity of the cæcum is just internal to the middle of Poupart's ligament.

Intussusception

The ilio-cæcal valve is the commonest place for intussusception to commence.

Appendix vermiformis

The appendix, usually about four inches long, may measure anything from one to twelve inches. It lies as a rule to the left of the cæcum, behind the lower end of the ileum with its apex in a line drawn from the cæcum to the spleen. It is often in close relation with the iliac vessels and the ureter, and is not infrequently found in the pelvis or behind the cæcum. These varying relations introduce an

element of difficulty into the operation of extirpating the appendix.

The appendix may, it is said, have no serous coat, but occupy a "retro-peritoneal" position in the cellular tissue behind the cæcum. A search for it in such a case would probably be unsuccessful.

The appendix may contract adhesions and assist in the formation of bands which may strangulate the intestine. It often contains concretions in its lumen, and appendicular inflammation is the commonest cause of the abscesses so often met with in this region.

In these cases pain on pressure is said to be most distinctly felt at a spot one and a half inches from the anterior superior spine of the ilium in a line drawn from that prominence to the umbilicus. This is "McBurney's point," and is usually chosen as the centre of an incision planned for reaching the appendix. As a fact the tender spot is usually below the line. The local swelling felt in cases of recurrent appendicitis may be an enlarged appendix, a swollen lymph gland in the mesentery of the appendix, matted coils of bowel, or thickened omentum or a local muscular contraction in the abdominal wall may simulate an intra-abdominal swelling.

McBurney's point

Given a stimulus applied to a viscus, *e.g.*, inflammation of a local intestinal area, that stimulus reaches the spinal cord and gives rise to (*a*) pain over the area of the spinal sensory nerves corresponding to that segment of the cord either unilateral or bilateral; (*b*) hyperæsthesia of skin

and muscle over the same area; (*c*) contraction (local) of the muscles over the area supplied by the corresponding motor branches the "viscero muscular reflex." This last may be spread over a much wider area than that corresponding to the lesion, or may be localised to a narrow zone. Conversely a lesion in the cord may cause pain referred to the viscera.—*Vide* James Mackenzie, *Brit. Med. Jour.*, 11/7/03.

Colon

The posterior relations of the ascending and of the descending colon are the most important surgically. At their upper ends they lie in front of the kidneys, but below the umbilicus each rests on the quadratus lumborum muscle of its respective side, and here lumbar colotomy used to be performed. The colon is indicated on the surface by a line drawn vertically upwards to the last rib from a point half an inch behind the centre of the iliac crest. The ascending colon in 26 per cent. and the descending in 36 per cent. of cases are completely surrounded by peritoneum (Treves). Colotomy in such circumstances must open the peritoneal cavity.

Colotomy

Mesocolon

Sigmoid flexure

Iliac colon

Pelvic colon

The portion of the colon formerly named the sigmoid flexure is now described as consisting of the "iliac colon," which extends from the level of the iliac crest to the brim of the pelvis and is unprovided with a mesentery. The "pelvic colon" extends from the above to the level of the third sacral vertebra and forming a loop includes the bowel formerly called the first part of the rectum. The pelvic colon has a well-developed mesentery, but its length

and course are variable. In operations in this section of the bowel it is clear that the ease or difficulty with which a loop of bowel is drawn out of an inguinal incision will vary considerably.

Owing to the considerable length of the loop, the narrow parietal attachment of its mesentery and the frequent loading of this part of the bowel with heavy fæces, the sigmoid flexure is a common site of "volvulus."

Volvulus

Inguinal colotomy

The operation of "inguinal" colotomy is performed through an incision bisected by and at right angles to a line drawn from the umbilicus to the anterior superior spine of the ilium and one and a half inches from the latter point. The presence of longitudinal bands of muscular fibre and the appendices epiploicæ distinguish the large from a coil of small intestine.

It may be noted that the continued presence of hard fæces in the sigmoid flexure may cause pressure on the external iliac vein and lymphatics, and give rise to œdema of the left leg or varix, or to pain by pressure on nerves.

Peritoneal Pouches

Two peritoneal pouches, or duodenal fossæ, are usually found at the point where the duodenum turns forwards to join the jejunum. One of these, the superior, is open downwards, the inferior or fossa of Treitz is open upwards. These fossæ are formed by folds of peritoneum passing from the duodenum to the posterior abdominal wall or to the mesocolon. A third, the paraduodenal fossa of Landzert, is formed by a fold in the free edge of which runs the inferior mesenteric vein. This fossa

lies some distance to the left of the last part of the duodenum, and is open to the right. Into it a left duodenal hernia protrudes. The importance, surgically of these fossæ lies chiefly in this possibility of their becoming the seat of internal hernia. Some other fossæ of less surgical importance and less constancy are also described by various writers, and especially by Moynihan. Acquired fossæ also sometimes occurs as the result of inflammatory changes.

In the neighbourhood of the cæcum other pouches are to be found, viz., (1) the retrocæcal, retrocolic, or subcæcal fossa, lying behind either the inner or outer part of the ascending colon. (2) The anterior vascular, ileocolic, or superior ileocæcal fossa is bounded by a fold raised by the continuation of the main trunk of the ileocolic artery; the fossa lies between the fold in front, and the mesentery, ileum and cæcum behind. (3) The ileo-appendicular or inferior ileocæcal fossa lies behind the ileo-appendicular fold and the meso-appendix. These cæcal fossæ have some importance as regards the position of the appendix, which may, for example, lie in the retrocæcal fossa, as well as in regard to hernia. An inter-sigmoid fossa is to be found on the under surface of the meso-sigmoid or mesentery of the "pelvic colon" over the bifurcation of the common iliac artery. Most of the above information is taken from an editorial article on Mr. Moynihan's book on "Retroperitoneal Hernia," vide *Annals of Surgery*, January, 1903.

Transverse colon

The transverse colon passes across the abdomen in a course convex downwards from the right to the

left hypochondrium. The splenic flexure is placed higher and deeper than the hepatic. The first portion of the transverse colon is in relation with the gall-bladder, and gall-stones can ulcerate through from one into the other, after adhesions have formed. The gut then lies just below the greater curvature of the stomach, and usually crosses the middle line a little above the umbilicus; but its level varies greatly. The transverse colon can readily be opened through an appropriate incision in the middle line.

Arteries

The general course of the common and external iliac arteries has already been mentioned. The common iliac artery extends from the bifurcation of the aorta to the lumbo-sacral articulation. It runs along the inner border of the psoas. On account of the position of the vena cava to the right of the aorta, the right common iliac vein passes behind the corresponding artery, whilst the left vein leaves its companion trunk and joins the right vein behind the right common iliac artery.

Common iliac

External iliac

The external iliac runs along the inner border of the psoas muscle, coming to lie upon it at Poupart's ligament. The vein is internal to and on a slightly deeper plane than the artery. The artery is crossed near its origin by the ureter and by the sigmoid flexure on the left side, and the termination of the ileum on the right. Crossing in front of both vessels there are the genital branch of the genito-crural nerve, the vas deferens and the spermatic or ovarian arteries.

Internal iliac

The internal iliac artery runs from the bifurca-

tion of the common iliac at the pelvic brim to the upper margin of the great sciatic notch. The vessel is just beneath the peritoneum, and lies upon the lumbo-sacral cord. The vein is behind, and rather internal to the artery and the ureter in front of it near its origin. All these arteries can be tied through various curved incisions above Poupart's ligament, the peritoneum being preserved intact and stripped off the iliac fossa and brim of the pelvis; or a median abdominal incision may be made, the peritoneum covering the vessels incised, and a ligature applied in that way.

Perineum and Pelvis.

Perineum

The central point of the perineum is on the median raphe one inch in front of the anterior margin of the anus, or midway between the centre of the anus and the root of the scrotum. It is the meeting point of the sphincter ani, accelerator urinæ and transverse perineal muscles. Immediately in front of it is the posterior end of the bulb of the urethra. It marks the centre of the posterior border of the triangular ligament, along which is attached the fascia of Colles or deep layer of the superficial fascia. This fascia is attached laterally to the rami of the pubes and ischium. Thus, when urine is extravasated from a rupture of the urethra in front of the triangular ligament it is prevented from passing backwards beyond the centre of the perineum by the attachment of Colles' fascia to that ligament, from passing down the inner side of the thigh by the attachment of the fascia to the bony rami, and from burrowing deeply

Colles's fascia

Extravasation of urine

by the triangular ligament itself stretching across between the rami. It must therefore come forward and distend the cellular tissue of the scrotum, and may thence progress upwards on to the abdomen. Here its passage down the thigh is again arrested by the attachment of the deep layer of the superficial fascia, *i.e.*, Scarpa's fascia (beneath which the extravasation takes place), to the deep fascia of the thigh.

Scarpa's fascia

Superficial perineal structures

In the space between Colles' fascia and the triangular ligament are the bulb and spongy portion of the urethra covered by the accelerator urinæ muscle in the middle line, the erector penis on each side along the rami, and the transversales perinei muscles stretching backwards and outwards from the central point towards the ischial tuberosities, also the superficial perineal vessels and nerves.

Triangular ligament

The triangular ligament consists of two layers, superficial and deep, the last derived from the parietal pelvic fascia and stretching across from the bony rami to the apex of the prostate. The two layers are attached to each other posteriorly along the same line as marks the attachment of Colles' fascia to the superficial layer. Between the two layers are the membranous urethra, the compressor urethræ muscle, Cowper's glands, just behind the bulb on each side, the internal pudic vessels and the dorsal nerve of the penis running along the rami, also the artery to the bulb running towards the middle line about half an inch in front of the central point of the perineum and about one and a half

Deeper perineal structures

inches in front of the anus. Beneath the deep layer of the triangular ligament, separated from it by the levator ani, is the prostate surrounded by its plexus of veins and a fascial sheath. Its apex touches the ligament, about half an inch behind and a little below the sub-pubic angle, and can be felt per rectum about an inch and a quarter above the anus. This is an important guide to Cock's operation upon the urethra.

Apex of prostate

Behind the central point of the perineum is the anus in the middle line, and on each side the ischio-rectal fossa, bounded externally by the obturator internus covered by the obturator fascia, *i.e.*, the parietal layer of the pelvic fascia; internally, by the levator ani clothed by the anal fascia; in front, by the base of the triangular ligament and transversus perinei muscle; and behind, by the gluteus maximus, great sacro-sciatic ligament and coccygeus muscle. The fossa contains fat, the inferior hæmorrhoidal vessels and nerves, and in front the superficial perineal vessels and nerves. Running in the outer wall at a distance of about one and a half inches above the lower border of the ischial tuberosity, and placed in the special compartment of the parietal layer of pelvic fascia known as Alcock's canal, are the internal pudic vessels and nerve.

Anus

Ischio-rectal fossa

In median lithotomy the knife is entered just in front of the anus and pushed towards the apex of the prostate, guided by the finger in the rectum. It should enter the groove in the staff through the membranous urethra. The incision is enlarged

Median lithotomy

forwards to the extent of an inch, and the following parts divided:—Skin, sphincter ani, central point of perineum with posterior edge of triangular ligament, the membranous urethra and compressor urethræ muscle. It should be remembered that in adults the neck of the bladder is about three inches from the surface of the perineum, and that in children the organ occupies a relatively higher position; also that in them the prostate is only rudimentary, and hence the pelvic fascia is more easily opened up.

Rupture of the membranous urethra

In rupture of the membranous urethra the extravasated urine would at first be confined between the layers of the triangular ligament. It would then probably burst through the posterior layer and infiltrate the cellular tissue of the pelvis. If it passed through the superficial layer its subsequent course would be the same as after rupture of the spongy portion.

The urethra

The calibre of the urethra is of importance in relation to catheterism and the expulsion of small calculi from the bladder. The prostatic portion is the widest, and the meatus the narrowest. The membranous or muscular portion, with a diameter of about one-third of an inch, is also the most unyielding, owing to the rigidity of the aperture through the triangular ligament, and the most subject to compression and spasm, owing to the compressor urethræ completely investing it. In the roof of the fossa navicularis, near the end of the penis, is the lacuna magna, in which the point of a small catheter is so apt to catch, hence the instru-

Lacuna magna

ment should be kept along the floor of the canal for the first inch, but afterwards along the roof to prevent the point from catching in the sac of the bulb or in the sinus pocularis on the floor of the prostatic portion.

Sinus pocularis

The small threads seen in the urine of patients with prostatitis are casts of the tubules which open from the prostate into the urethra, and which may be the seat of calculi.

Prostatic tubules

The roof or floor of the urethra may be congenitally absent to a varying extent. The former condition or epispadias is usually combined with extroversion of the bladder. In the latter, known as hypospadias, the urine may be discharged through an abnormal opening on the median raphe, anywhere between the anus and the glans penis.

Epispadias

The laxity of the skin and subcutaneous cellular tissue of the penis and scrotum permits of great distension of these parts when they are the seat of fluid effusions, *e.g.*, serum, blood or urine, and greatly facilitates the many plastic operations performed in this region.

The descent of the funicular process of peritoneum has already been mentioned in relation to hernia, but its variations in connection with hydrocele must be remembered. Under ordinary conditions the peritoneal process is closed at the internal ring, and just above the testis, the intervening part being obliterated. Should, however, the whole canal remain open and fluid flow in from the peritoneum or collect in the pouch a "congenital hydrocele" would be present. If the obliteration were limited

Testicle

to the upper end, the lower remaining patent, the hydrocele would be an "infantile" one. If only a segment of the funicular process were distended an "encysted hydrocele of the cord" would exist, while finally, if the normal arrangement of the peritoneum were present but the tunica vaginalis was filled with fluid, an ordinary "vaginal hydrocele" would be the result. The testicle under ordinary conditions lies behind the peritoneal pouch, invaginating its posterior wall.

It is not necessary to go into the question of the development of the testicle here, but certain of the Wolffian and other relics which remain in the region of the testis may give rise to cysts and hence be of some surgical importance as explaining the origin of some of the forms of encysted hydrocele of the epididymis.

Thus the organ of Giraldès may by its distension form a cyst, and the vas aberrans, a Wolffian relic also, and the hydatid of Morgagni or relic of the Mullerian duct may be possible sources of small cysts.

For further particulars of these sacs the work of Jacobson should be consulted.

The dense unyielding structure of the tunica albuginea explains the severity of the pain felt in inflammation of the body of the testis and also to some degree the protrusion ("hernia testis") of the tubuli when by wound or syphilis or occasionally tuberculous disease perforation of the tunica has occurred.

In place of its normal position the testicle may be

retained in the abdomen or inguinal canal, or may be drawn backwards into the perineum.

The lymphatics of the testicle accompany the spermatic cord to the lumbar glands, and hence these become affected in malignant growths of the organ, while the lymphatics of the urethra and scrotum join the inguinal glands, and so give rise to the enlargements here which follow chancres, pediculi pubis, chimney sweep's cancer of the scrotum, and so on.

Varicocele

The spermatic cord is dealt with in the portion between the external ring and the testicle in treating "varicocele" or enlargement of the veins of the cord. The vas deferens lies on the posterior aspect of the cord, and is easily identified by its hardness to the touch. It must be excluded in passing the ligatures. The proneness of the spermatic veins to varicosity is explained by their length, natural tortuosity, deficiency in valves, generally vertical position, and the subjection of their upper parts to increased pressure in straining acts of the abdomen. The greater frequency of left-sided varicocele is explained by the more pendent position of the left testicle, by the pressure of a loaded sigmoid flexure on the left veins, and by the fact that the left spermatic vein opens at right angles into the left renal, while the right opens obliquely into the vena cava. It is not easy to understand the force of this last factor, especially as a valve usually exists where the left spermatic vein opens into the renal (Ellis).

The pampiniform plexus is enclosed in a thin fibrous sheath and packed with fat.

Cremasteric reflex

The cremaster muscle is supplied by the genito-crural nerve, whose crural branch is distributed over the middle of the groin and upper part of the thigh. Hence irritation of the skin in this region is followed by retraction of the testicle (cremasteric reflex).

The pain in the testicle, groin and thigh, and the retraction of the organ met with during attacks of renal colic, and the lumbar pain and vomiting often associated with injuries to the testicle are explained by the fact that the testicular, spermatic, renal and solar sympathetic plexuses are all continuous, so that painful impressions radiate and reflex phenomena are set up.

Prostate

The general position of the prostate with respect to the symphysis has already been noted. The apex of the gland is about one and half inches from the surface of the perineum. It is invested by its own capsule and outside this by the visceral layer of the pelvic fascia. Between the two lies a plexus of veins, and the gland is in contact behind with the end of the second part of the rectum, one layer of fascia intervening. The recto vesical pouch of peritoneum reaches down to within half an inch or an inch of the top of the prostate. Two inches may intervene when the bladder is distended.

Complete removal of the prostate is no doubt possible under the altered conditions that exist in disease but it is probable that many cases of so-called complete removal have been rather instances of enucleation of adenomata, which have so far compressed the normal prostate tissue that it

is reduced to a thin layer, hardly to be recognised during an operation as gland tissue at all, while in other instances it is possible that the whole gland, altered perhaps in its relation to its capsule and the pelvic "sheath," may have been removed. Layers of muscle fibre derived from the bladder or continuous at least with it have been found in some cases on the surface of the mass removed, while in other cases portions of gland tissue have been left behind.

Vesiculæ seminales

The vesiculæ seminales lie above the prostate between the bladder and the rectum, and can readily be felt per rectum when they are enlarged. They diverge from below upwards, and form with the line of reflection of the peritoneum a triangular space, through which the trocar is passed in tapping the bladder per rectum. When they are the seat of tuberculous disease or abscess, the vesicles can be reached by incision in front of the anus.

Abscess

A prostatic abscess usually bursts into the urethra, and, failing that, into the rectum, since the fascial capsule of the gland is thinnest posteriorly. Rarely the pus burrows beneath the capsule to the apex of the gland, and bursts through the posterior layer of the triangular ligament. Its progress upwards is resisted by the recto-vesical layer of pelvic fascia, which is continuous with the prostatic capsule round the base of the gland.

Hypertrophy

Enlargement of the lateral lobes of the prostate is easily made out per rectum. Hypertrophy of the "middle lobe" is usually only a projecting mass from one lateral lobe. Either condition may give

rise to urinary trouble, the enlarged "middle lobe" protruding forwards into the bladder and closing in a valve-like manner the vesical orifice of the urethra, and the lateral masses forming a collar-like ring round the internal urethral orifice or obstructing it by direct pressure. Hypertrophy of the lateral lobes increases the length and produces deformity and tortuosity of the prostatic portion of the urethra.

Bladder

The empty bladder lies entirely below the brim of the true pelvis, but the distended organ may reach any level between that and the umbilicus. The posterior convexity of the bladder is covered by peritoneum to within an inch of the base of the prostate, and, when the viscus is distended, its enlarged fundus and anterior surface are partly covered, the reflexion of the serous membrane extending downwards in front of the bladder to within one and a half inches of the upper border of the symphysis pubis. This interval is rarely increased to more than two inches, however great the distension of the bladder. Roughly, half the extent of anterior wall above the pubes is uncovered by peritoneum. Through this interval the organ is tapped and supra-pubic lithotomy performed.

Distention

Suprapubic lithotomy

Vesical orifice of the urethra

The internal orifice of the urethra is about an inch behind the upper part of the symphysis pubis and two and a half to three inches from the surface of the perineum. This landmark is useful in operations on the prostate and in judging the depth of a puncture necessary for perineal drainage of the bladder. The orifice descends when the organ is

distended, and occupies a relatively higher position in young children and in cases of hypertrophied prostate.

Hypertrophy of bladder

In the hypertrophy of the muscular coat of the bladder which follows obstruction to the urinary outflow, the detrusor muscle on the anterior surface and the muscular band stretching between the orifices of the ureters bear a conspicuous part.

Sacculated bladder

The mucous membrane is apt to bulge and form sacculi between the hypertrophied bundles, arranged as they are in a spiral or figure of 8 fashion, and in these phosphatic deposits and calculi may lodge.

The hard projecting ridges of hypertrophied muscle fibres are readily felt by a sound in the bladder, and may cause errors in diagnosis.

Rectum

The *first part of the rectum* extends obliquely from the brim of the pelvis to the third piece of the sacrum. It has a complete investment of peritoneum, and the superior hæmorrhoidal arteries pass down on each side of it. *Vide* "pelvic colon."

The *second portion* lies upon the lower segment of the sacrum and the coccyx, and is in relation in front with the trigone of the bladder, the vesiculæ seminales and the posterior surface of the prostate. It is covered by peritoneum anteriorly in its upper part, the recto-vesical pouch extending to within three inches of the anus. On the posterior surface of the gut there is no peritoneum below a point five inches from the anus. These two points limit the amount of bowel

that can be removed without opening the peritoneum.

Internal sphincter

"Anal canal"

The *third part of the rectum*, or "anal canal," one inch long, extends downwards and backwards from the tip of the coccyx to the anus, forming an angle with the second part. It is surrounded for an inch above the anus by the internal sphincter, and between the muscle and mucous membrane is the inferior hæmorrhoidal plexus of veins whose abnormal dilatation constitutes "piles."

Piles

The rectum, according to modern description, extends from the termination of the "pelvic colon" at the third sacral vertebra downwards to the level of the lower part of the prostate, at which point it narrows into the "anal canal" or third part of the rectum. So described the rectum has posteriorly the sacrum, coccyx, and levatores ani, with intervening connective tissue, and at the upper part the hæmorrhoidal vessels, which become lateral lower down. In front the recto-vesical pouch, with its contents, separates it from the bladder to within an inch of the prostate (3 in. from the anus). Lower down the bladder, vasa deferentia, vesiculæ seminales and prostate are separated from it by the recto-vesical fascia. In the female the pouch of Douglas above and the vagina below are the anterior relations.

Folds of mucous membrane

The mucous membrane of the rectum presents three oblique folds (Houston), against which the tip of a rectal bougie may hitch. Two are on the left

side, and the highest of all on the right, about the level of the peritoneal reflection.

Examination per rectum

The upper part of the rectum is insensitive and very dilatable, and since the anus may, with care, be dilated so as to admit a medium-sized hand, very extensive examinations are possible per rectum. It is to be understood that introduction of the entire hand is seldom possible and still less often desirable, but rectal examination with one or two fingers is invaluable. The rectal aspect of the prostate, the region of the trigone of the bladder, the anterior surface of the coccyx and sacrum, the obturator foramen, the pelvic surface of the acetabular floor, the brim of the true pelvis, the iliac glands and arteries, the pelvic peritoneal pouch, and to a certain extent the iliac fossæ can all be examined and the two sides compared. Tumours, ulcers, strictures of the rectum, enlargement of the prostate and vesiculæ seminales, distension of the bladder, abscess due to disease of the coccyx, sacrum, acetabulum, iliac glands, pelvic suppuration, appendicular peritonitis, as well as many other conditions, may be investigated. Combined examinations, such as abdomino-rectal, recto-vaginal or abdomino-recto-vaginal, are of much service.

Pelvic fascia

The pelvic fascia consists of two distinct portions, a parietal and a visceral. The parietal layer, as the name indicates, forms a lining to the cavity of the true pelvis, certain parts of it receiving special names according to the structures which they cover, as, for instance, obturator fascia, deep triangular

ligament. It should be remembered, however, that though thus differentiated, they are but portions of one continuous layer. The visceral layer arises from the parietal layer along a line extending from the ischial spine to the lower part of the symphysis pubis, and practically forms a transverse septum extending across the pelvis, though the arrangement is complicated by the pelvic viscera receiving special investments. The line of origin of the visceral layer of the pelvic fascia from the parietal is known as the white line, and serves for the attachment of fibres of the levator ani muscle.

The under surface of the levator ani is covered by a thin layer of fascia, which is connected to the pelvic fascia along the white line. This fascia, which is known as the anal fascia, is merely the sheath of the muscle.

These musculo-fascial barriers prevent intra-pelvic collections of fluid from reaching the perineal surface, and shut off superficial perineal abscesses from access to the pelvis. Thus an ischio-rectal abscess cannot, by reason of the anal fascia and levator ani, burrow upwards along the rectum, and is compelled either to open externally or into the bowel between the two sphincters. If it makes its way further up the side of the bowel it is by penetrating between the muscular and mucous layers in the submucous tissue.

Ischio-rectal abscess

The anus

The anus is surrounded by the external sphincter, and the skin of the region is puckered by the action of this muscle and of the corrugator cutis ani.

Dilatation of the surface veins round the margin of the anus causes "external piles." External piles

The "white line" round the anus marking the junction of the skin and mucous membrane and the interval between the internal and external sphincters is a useful landmark in operations about this region. Wounding or cauterising the mucous membrane is not followed by any considerable pain nor removal by the risk of stricture. The reverse is the case with regard to the skin. "White line" of Hilton

The skin of the penis, scrotum and perineum as far as the posterior margin of the anus, the muscles of the perineum and the mucous membrane of the urethra and of the lower end of the rectum are all supplied by the pudic nerve, and irritation of one of its branches may be referred by the brain to the distribution of other branches. Hence associated reflex phenomena and "referred" pains are very common about this region. Thus the "painful fissure" caused by the exposure of a sensory filament of the inferior hæmorrhoidal nerve on the surface of a small crack or ulcer near the anal margin is usually accompanied by reflex contraction of the sphincter ani and often by spasm of the other perineal muscles, causing retention of urine or erection of the penis. A familiar example is retention of urine following an operation for "piles"; here the afferent nerve is the inferior hæmorrhoidal and the motor impulse travels either through the pudic to the constrictor urethræ or through the third sacral nerve to the neck of the bladder. "Chordee" is a reflex spasm of the Nerves Fissure of the anus "Chordee"

erector penis, caused by a painful condition of the urethra.

Pain applied to one sensory branch may be referred by the brain to the distribution of contiguous nerves, as well as to other branches of the same nerve. Thus the pudic nerve arises from the second, third and fourth sacral nerves, and the small sciatic supplying the skin of the buttock in part and the back of the thigh arises from the first, second and third. Hence pains affecting the distribution of the pudic or the visceral branches of the third or fourth sacral nerves may be referred to that of the small sciatic, giving rise to pain in the buttock and back of the thigh. This association is strengthened by the long pudendal branch of the small sciatic which supplies part of the scrotum. The third sacral nerve gives a visceral branch to the bladder, the fourth and fifth sacral to other pelvic viscera. The fourth sacral is associated with the pudic in the supply of the sphincter ani, and gives also branches to the levator ani and coccygeus muscles. Hence spasm of any of these muscles as well as pain along the cutaneous distribution of the pudic may be met with in painful conditions of the pelvic viscera. Pain at the end of the penis often accompanies vesical calculus, prostatitis, tuberculosis of the vesiculæ seminales, etc.

When the inhibitory action of the cerebrum is withdrawn from the lumbar centres of the cord by a crush higher up the various reflex acts connected with the lumbar enlargement occur with abnormal facility. Micturition under such circumstances is

an entirely reflex act, while priapism is readily produced by the slightest irritation of the parts, *e.g.*, pinching the skin of the scrotum, passing of a catheter, etc.

Female Genital Organs.

Bartholin's glands

The position of Bartholin's glands between the layers of the triangular ligament beneath the labia at the level of the posterior margin of the vagina is made evident when they are the seat of abscess.

Lymphatics

The lymphatics of the vulva pass to the glands of the groin, which may be enlarged in cases of gonorrhœa, chancre, pediculi and malignant growths of this region.

Vagina

The vagina is two and a half inches long, and is in contact with the rectum behind and the urethra and base of the bladder in front. Hence the facility with which urethro-vaginal, vesico-vaginal and recto-vaginal fistulæ may be produced.

Urethra

The short, straight course of the female urethra, parallel to the anterior vaginal wall, renders its dilatation easy, and digital exploration of the lining of the bladder possible per urethram.

The neck and base of the female bladder may be opened and calculi extracted through the vagina.

Uterus

The normal uterine canal is two and a half inches long, of which length one inch belongs to the cervix.

The fold of peritoneum between the bladder and uterus descends to the level of the internal os, but the peritoneum of the pouch of Douglas between

the uterus and rectum covers the uterus as far as the middle portion of the neck and the upper inch of the posterior vaginal wall.

Broad ligaments The peritoneal layers of the broad ligaments are in contact at their upper parts after investing the Fallopian tubes, but separate below, where they are reflected to the sides of the pelvis. The space between the peritoneal layers is occupied by pelvic cellular tissue and uterine arteries, nerves and lymphatics. Hence inflammatory conditions and malignant growths of the uterus spread to this tissue with great facility.

The Ovaries The ovary is invested by the posterior peritoneal layer of the broad ligament, just below the Fallopian tube.

Arteries ovarian The ovarian artery runs between the layers of the broad ligament just below the ovary, from the brim of the pelvis to the junction of the uterus and Fallopian tube. The ligature of the pedicle in ovariotomy secures this artery in two places, between the ovary and the pelvic brim, and between the ovary and uterus, a complete piece of the vessel being removed with the tumour.

Uterine The uterine artery passes inwards across the floor of the pelvis to the side of the neck of the uterus, where it anastomoses with the vaginal arteries below and along the side of the uterus with the ovarian artery. This artery and some of its branches are divided in the operation of hysterectomy.

Ureter The pelvic course of the ureter in the female must be noticed.

After passing over the division of the common iliac vessels at the brim of the pelvis the ureter lies in front of the internal iliac artery. It then passes obliquely inwards beneath the broad ligaments to reach a point half an inch external to the cervix uteri. In this part of its course it is crossed anteriorly by the uterine artery as that vessel passes towards the cervix. The ureter then comes into direct relation with the upper and anterior part of the vaginal wall, and lies between the bladder and vagina for about an inch till it pierces the wall of the former. It will thus be seen that the ureter may be inadvertently included in one of the lateral ligatures or clamps when the uterus is being excised, and also that a uretero-vaginal fistula may occur after severe intra-vaginal pressure.

Uretero-vaginal fistula

Pelvic Bones.

The coccyx is sometimes removed entire for the relief of severe neuralgic conditions of the region. The relation of the rectum to the anterior surface of the bone must be remembered.

Coccyx

The region of the coccyx often presents congenital tumours, which are supposed to originate in persistent fragments of the primitive post-anal gut or the neurenteric canal.

Congenital tumours

The coccyx and lower inch of the sacrum can be removed without injury to important nerves, and through the opening thus made the rectum can be excised at a considerably higher level than is possible by working from the perineum, but if the

Sacrum

sacrum be divided above the third foramen paralysis of the bladder will ensue, since the chief motor supply to that viscus comes from the third sacral nerve.

LOWER EXTREMITY.

Fascia lata

The dense fascia lata encasing the thigh is attached to Poupart's ligament in front, and thus it becomes continuous with the external oblique aponeurosis, while laterally and posteriorly it is directly attached to the iliac crest, the sides of the sacrum and coccyx, and the ischial and pubic rami. Just in front of the great trochanter it receives the insertion of the tensor vaginæ femoris, and below and behind that prominence it is fortified by an expansion from the gluteus maximus. Below, the fascia is attached to the bony points around the knee. The specially strengthened portion of this fascia, known as the ilio-tibial band, is on the outer aspect of the limb, and is firmly attached to the crest of the ilium and the outer tuberosity of the tibia. The strength of this fascial sheath is of the utmost surgical importance in limiting the spread of solid growths and collections of fluid towards the surface, and some of the complications liable to occur in the neck as a result of confinement of pus are liable also to occur in the thigh for a similar reason. The band which normally helps to support the rigidity of the limb in the erect posture, is relaxed at its upper part in

The tibial band

cases of fracture of the neck of the femur accompanied by shortening.

Saphenous opening

The weakest part of this sheath is at the saphenous opening, about one and a half inches below and external to the pubic spine, where the cutaneous veins and lymphatics pass inwards.

Femoral hernia

Since the crural sheath lies directly behind the upper part of this opening, a femoral hernia in its descent will protrude through it. The hernia comes down through the crural canal or inner compartment of the femoral sheath, passing beneath the deep crural arch, *i.e.*, the thickened lower fibres of the transversalis fascia, which stretch from the middle of Poupart's ligament over the vessels and crural ring, to be inserted into the ileo-pectineal line behind Gimbernat's ligament. Thus the hernia passes beneath Poupart's ligament into the thigh. Since the femoral sheath is blended with the tunica adventitia of the vessels below the level of the saphenous opening, the crural canal no longer exists, and the hernia can descend no further along the vessels. It therefore turns forwards in the line of least resistance through the saphenous aperture.

Deep crural arch

Direction of the hernia

After emerging through this opening the hernia usually turns upwards and outwards. This movement is probably determined by several factors.

1. The cribriform fascia is more firmly attached to the lower than to the upper margin of the aperture.

2. The movements of flexion of the thigh.

3. The sharp falciform border of the saphenous opening which presses upon and retards the move-

ment of the upper part of the protruded bowel. The lower part, being forced on from above, revolves round this sharp edge and takes a direction upwards and outwards.

Herniotomy

Hence in an operation for femoral hernia the incision is made over the inner side of the swelling so as to reach more directly the point of exit from the abdomen and the seat of constriction, usually the free edge of Gimbernat's ligament, occasionally the deep crural arch.

Septum crurale

The crural canal contains a lymphatic gland and some fat, and stretching over its upper aperture or the crural ring is the extra-peritoneal fatty tissue, which forms the septum crurale.

Crural ring

The crural ring or abdominal opening of the crural canal is bounded in front by Poupart's ligament, behind by the fascia covering the pectineus muscle, internally by the sharp edge of Gimbernat's ligament, and externally by the femoral vein.

Layers of sac

A femoral hernia pushes before it:

1. Peritoneum.
2. Septum crurale (sub-peritoneal fat).
3. Fascia propria (derived from the femoral sheath).
4. Cribriform or deep layer of the superficial fascia.
5. The superficial layer of the same fascia.
6. The skin.

In dividing the resisting structures to reduce the hernia the knife edge is directed inward, and Gimbernat's ligament notched. An upward incision

would endanger the spermatic cord and divide Poupart's ligament, causing a probable permanent weakness at that spot; an outward incision would wound the femoral vein; and a backward one would come directly upon the pubes.

Abnormal obturator artery

The rare abnormality of the obturator artery when it arises from the deep epigastric and courses down on the inner side of the crural canal upon Gimbernat's ligament, need only be mentioned. In such a case a wound of it in femoral herniotomy would be inevitable, but would probably be recognised at the time and dealt with by enlarging the external incision and ligaturing the vessel.

The sac of a femoral hernia is nearly always very easily separated from surrounding parts, so that there is no difficulty in isolating, ligaturing and removing it after the operation for hernia. A lobulated layer of fat often surrounds the sac, and may cause confusion, as it closely resembles omentum.

Internal saphenous vein

The internal saphenous vein, passing through the saphenous opening, may, if varicose at that spot, give rise to a swelling simulating at first sight a small femoral hernia.

Inguinal glands

The lymphatic glands in the region of the groin are of importance because of the numerous sources from which they may be infected.

Superficial

The superficial glands are arranged in two groups—a horizontal along Poupart's ligament, and a vertical near the saphenous opening.

The inner horizontal glands receive lymphatics from the genitals, and are the common seat of

Horizontal group "bubo"

"bubo," the middle horizontal glands receive vessels from the abdominal wall, and the outer from the surface of the buttock.

Vertical group

The vertical superficial glands receive the superficial vessels of the leg, which run chiefly up the inner aspect of the limb. These are the first to be enlarged in poisoned wounds or epitheliomata of the lower limb. The efferent vessels of the superficial glands pass through the cribriform fascia, some to join the deep inguinal glands, others to open into the glands along the external iliac artery.

Deep set

The deep glands are situated over the femoral sheath, and receive the deep lymphatics which accompany the main vessels of the limb. All these glands are connected by vessels, and drain into the glands along the external iliac artery.

Scarpa's triangle

Scarpa's triangle is bounded above by Poupart's ligament, which forms its base, and laterally by the inner borders of the sartorius and adductor longus but if the outer border of the adductor longus be taken this boundary will still include all the important structures of the space, and the apex of the triangle will then be at the junction of the upper and middle thirds of the thigh.

Femoral artery

The direction of the common and superficial femoral arteries is represented by the upper two-thirds of a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle of the femur.

Profunda and circumflex arteries

The profunda arises about one and a half inches, and the circumflex arteries from the profunda two inches below Poupart's ligament.

The level at which the common femoral artery divides into superficial femoral and profunda is subject to considerable variation either way, and this may be of much surgical importance.

Femoral vein

The femoral vein is at first internal to the artery, but at the apex of Scarpa's triangle is posterior to it.

Anterior crural and Internal cutaneous nerves

The anterior crural nerve is external to the artery, but the internal cutaneous branch crosses the vessel from without inwards near the apex of Scarpa's triangle.

In this part of its course the artery lies upon the psoas, pectineus, and adductor brevis muscles, the nerve from the anterior crural to the pectineus, and the profunda artery and vein near the apex of the space; superficial to it are the vertical group of inguinal glands and the crural branch of the genito-crural nerve.

The vessel crosses the head of the femur, separated from it by the capsule of the joint and the psoas muscle, but owing to the length of the neck it only comes into contact with the shaft of the bone at the apex of Scarpa's triangle. In compressing the femoral artery at its origin the pressure should be directed backwards against the fixed pubic ramus, and not against the movable head of the femur. Lower down the pressure must be applied mainly outwards so as to compress the vessel against the shaft of the femur.

Place of election or ligature

The lower part of Scarpa's triangle, a broad hand's breadth below Poupart's ligament, is the place of election for ligature of the superficial femoral

artery, which is here immediately beneath the fascia.

Hunter's canal

An alternative site is in Hunter's canal, which is occupied by the vessel in the middle third of the thigh. The artery lies in a channel formed by the bridging over of the space between the vastus internus and the adductores longus and magnus by a process of the deep fascia, which, again, is covered by the sartorius. In this canal the femoral vein lies at first behind the artery, but in the lower third comes to the outer side of that vessel, and the long saphenous nerve overlies the sheath. A branch of the obturator nerve to the knee joint also accompanies the vessel, and the nerve to the vastus internus lies to its outer side. In opening Hunter's canal to reach the artery the sartorius is usually drawn inwards, but may be displaced outwards if that should seem more convenient.

Collateral circulation

After ligature of the superficial femoral the circulation is carried on by means of the following anastomoses:—

1. The termination of the profunda with the superior muscular branches of the popliteal.

2. The external circumflex branch of the profunda with the gluteal, ilio-lumbar and deep circumflex iliac arteries above and the superior and inferior external articular branches of the popliteal and the posterior tibial recurrent below.

3. The internal circumflex artery, with the sciatic, gluteal and obturator above and the first perforating branch of the profunda below.

4. The anastomoses of the perforating branches

with each other, with the terminal branch of the profunda or fourth perforating, and with the comes nervi ischiadici from the sciatic.

Apart from the question of collateral circulation after closure of the superficial femoral, the branches of the profunda are chiefly of importance surgically in relation to amputations of the thigh and operations about the hip, such as excision, where branches of the internal or external circumflex may be divided in extensive incisions. The profunda itself lies behind Hunter's canal in the middle of the thigh in the plane between the adductor longus and adductor magnus.

Anastomotic artery

The anastomotica magna is surgically the most important branch of the superficial femoral, since in its course along the adductor magnus tendon it has more than once been divided in osteotomy of the lower end of the femur and other operations.

Nerves of thigh

The chief points of importance surgically about the nerves of the front of the thigh are that irritation of the cutaneous crural branch of the genito-crural is used as a test of reflex action; that the branches of the obturator nerve to the obturator plexus and the hip and the back of the knee joint explain in some cases the pain felt in the thigh and knee in hip-joint disease, though perhaps it is more common for the pain to be referred to the branches of the anterior crural, which similarly supply both joints. Mr. Hilton, using this instance of referred pain as one of his favourite illustrations of that important subject, specially points out that in this, as in other localities, strong local sedative applications applied

Cremasteric reflex

to the seat of pain do relieve that pain, though such applications are far away from the actual disease which causes the pain. In some cases of varix of the internal saphenous vein the distended and tortuous vessel presses upon the branches of the internal saphenous nerve, and so causes pain. In one such case one of the writers removed a portion of the nerve in Hunter's canal to relieve this pain, which apparently depended upon cicatricial contraction about some obliterated portion of the vein.

Internal saphenous vein

The internal saphenous vein runs in a line from the back of the internal condyle to the saphenous opening. The vein is sometimes ligatured at its upper part (Trendelenburg), or a portion excised as a measure of relief in cases of varix, and the course of the vessel may not be apparent in an obese subject.

Operations for necrosis of femur

Mention has already been made of the strong and important aponeurotic ilio-tibial band, and it is noteworthy that between it and the biceps tendon on the outer side of the thigh in its lower third is an interval in which access can be readily gained to the femur in operations for necrosis without endangering any important structure.

In connection with the deeper parts of the front of the thigh the following points may be noticed.

Operations on hip by anterior incision

Vertically below the anterior superior spine of the ilium is the interval between the sartorius and tensor vaginæ femoris. Through this interval the hip joint is approached in operating by the anterior method.

Psoas bursa

The bursa between the psoas and the capsule of the hip joint may be enlarged, and form a swelling in the upper part of Scarpa's triangle, causing pain by stretching of the anterior crural nerve over it.

Obturator hernia

An obturator hernia, lying first beneath the pectineus and above or below the obturator vessels, is said to be most readily felt by a finger passed beneath or below the adductor longus tendon. Rectal or vaginal examination will usually also give help in such a case. The pressure of the tumour on the obturator nerve often causes pain in the distribution of that trunk.

The buttock

The chief bony points about the buttock are the anterior superior iliac spine, the great trochanter and the tuber ischii. A straight line (Nelaton's), drawn from the anterior superior spine to the tuber ischii, will, in the natural relation of the parts, pass through the top of the trochanter. Hence if the trochanter does not meet this line some displacement from dislocation, fracture or disease is at once suspected.

Nelaton's line

Bryant's line

Bryant's method of testing the same relation is to let fall a vertical line from the anterior superior spine to the plane surface upon which the body lies supine. The distance between this line and the top of the great trochanter is measured and compared with the opposite side.

The fold of the buttock

The "fold of the buttock" does *not* correspond with the lower edge of the gluteus maximus, which crosses it obliquely, lying above near the origin of the muscle and below near its insertion. The fold is diminished or obliterated by flexion and abduc-

tion of the hip, and the prominence of the buttock is still further diminished by the muscular wasting which occurs in the later stages of joint disease.

Posterior iliac spines

The posterior superior and posterior inferior iliac spines can be localised by tracing backwards the crest of the ilium. The superior spine is the most distinct and the more important as a land-

Sacro-iliac joint

mark. A line between the two spines represents the sacro-iliac joint on the posterior surface. Swelling may be detected and pain elicited by local pressure in this region when the joint is diseased. The line will also indicate the position of an incision suitable for opening the sacro-iliac joints when it is desired to approximate the pubes in the operation for extroversion of the bladder. The obturator nerve passes over the anterior surface of the sacro-iliac joint, and supplies a twig to it. Hence pain due to disease of the articulation may be referred to other areas of distribution of this nerve, *e.g.*, to the hip or knee joints. The supply from the sacral nerves may also give rise to "referred" pain.

Gluteal artery

The point of emergence of the gluteal artery from the pelvis at the upper margin of the great sacro-sciatic notch above the pyriformis is indicated by the junction of the upper and middle thirds of a

Sciatic artery

line from the posterior superior iliac spine to the top of the great trochanter; that of the sciatic artery below the pyriformis is at the junction of the lower and middle thirds of a line from the same iliac spine to the tuber ischii.

Great sciatic nerve

The course of the great sciatic nerve is marked

by a line drawn in the long axis of the limb midway between the great trochanter and the tuber ischii, and the nerve can readily be reached at a spot just below the point where the biceps muscle crosses this line, or higher up at the lower border of the gluteus maximus before it is crossed by the biceps.

Bursæ of the buttock

Besides the bursa already mentioned between the capsule of the hip joint and the psoas tendon, various other sacs should be remembered in connection with the joint and the region of the buttock, since any of them may be enlarged or inflamed, and some are frequently so. Suppuration in these bursæ may give rise to disease of the underlying bone.

The most constant bursæ are:—

1. One between the gluteus maximus and tuber ischii, often enlarged in people who follow a sedentary occupation which yet necessitates friction of the parts ("waterman's bottom, weaver's bottom"). Hilton records cases illustrating the ill effects of pressure by an enlarged bursa upon the inferior pudendal nerve.

2. One between the gluteus maximus and the great trochanter.

3. One between the gluteus medius and the great trochanter.

4. One between the gluteus minimus and the great trochanter.

5. One between the obturator internus tendon and the grooved surface of the ischium.

6. One between the obturator internus and the back of the hip joint. When one of these sacs is

inflamed the position of greatest ease will be that which most relaxes the muscle over the bursa.

Hip joint

The hip joint lies deeply, and is covered on all its aspects by muscles. The centre of the acetbulum is level with the top of the great trochanter,

Position

and the head of the femur is represented on the surface by a point just below and external to the centre of Poupart's ligament.

Y-shaped cartilage

The Y-shaped cartilage separating the three segments of the acetabulum is not completely ossified till the 18th year, hence in most cases of hip disease it remains as a possible path by which inflammation may spread from the joint to the inner pelvic surface, and is itself an epiphysial line in which disease not rarely begins.

Capsule of joint

The capsule of the joint is attached to the innominate bone round the rim of the acetabulum and to the transverse ligament bridging over the non-articular interval. Its attachment to the femur runs along the whole length of the anterior intertrochanteric line and along the posterior aspect of

Fractures of neck of femur

the neck half an inch internal to the posterior intertrochanteric line. It will thus be seen that no fracture of the neck of the femur can be entirely extra-capsular, and none can be entirely intracapsular which extends within half an inch of the root of the neck posteriorly.

Dislocations of hip

The capsule is weakest below and posteriorly, and the rent is found at this part in all ordinary dislocations. After escaping, the head of the bone first lies below the acetabulum, and is then directed backwards on to the dorsum ilii or forwards on to

the pubes in different cases according to the attitude of the limb at the time of the accident and the direction of the violence.

Ilio fermoral ligament of Bigelow.

The capsule is thickened by various accessory bands, and of these the ilio-femoral or Y-shaped ligament of Bigelow is the most important. It is attached to the anterior inferior iliac spine and to both extremities of the anterior inter-trochanteric line of the femur. It is never ruptured in ordinary dislocations of the femur, and has much influence in directing the course of the head after it has escaped from the acetabulum. The manipulations employed for reducing dislocations have for their object the relaxing of this band and its employment as a fulcrum in directing the return movements of the upper end of the femur. The ligament also has an influence in determining some of the positions assumed in different stages of hip disease.

Flexion of the thigh relaxes the whole ligament, and consequently lessens the pressure which it exerts on parts inside the capsule. The upper limb of the ligament is slackened by inward rotation of the thigh and the lower limb to a less extent by outward rotation.

Ligamentum teres

The ligamentum teres, besides resisting dislocation and influencing to some extent the positions assumed in hip disease, is important as providing a source of blood supply to the head of the femur and preventing necrosis of the upper fragment in cases of intra-capsular fracture of the neck of the bone. The reflected part of the capsule ensheathing

the neck largely helps in maintaining the nutrition of the head.

Nerves of hip joint

The frequency of sympathetic pain in the knee in hip joint disease is explained by the fact that both joints are supplied by the same nerves, the anterior aspect of both joints by the anterior crural, the posterior and inner aspects by the obturator, the posterior and outer aspects by the great sciatic. The hip joint also receives a twig from the sacral plexus by means of the nerve to the quadratus femoris.

Epiphyses of femur

The head and the epiphysis of the great trochanter join the shaft of the femur about the 18th year. This point is of value in judging the possibility of an injury having caused separation of the epiphysis, and also because of the frequency with which hip disease begins in the bone near the epiphysial line.

Amputation at hip joint

A knife passed deeply through the thigh from a point midway between the anterior superior spine and the great trochanter to a point as near as possible to the tuber ischii, crosses immediately in front of the hip joint, and may open the capsule. This is the first manœuvre in the transfixion operation for amputation at the hip. The main vessels are in the anterior flap.

The shaft of the femur is best approached from the outer side in operations.

Inequality of lower limbs

In estimating the efficacy of treatment in fracture of the shaft and in diagnosing various other

conditions, it should be remembered that in most cases there is about a quarter of an inch difference between the lengths of the two limbs.

The Knee.

Bony points, condyles of femur

Of the two femoral condyles, the inner is the more prominent; but the cartilaginous covering of the outer is the more extensive. The adductor tubercle on the inner condyle marks the level of the epiphysial line of the lower end of the femur and of the upper limit of the articular cartilage.

The ridge upon the outer condyle of the femur bounding the trochlear surface is much more prominent than the corresponding ridge on the inner condyle. This point is of interest, since dislocations of the patella are more apt to occur outwards than inwards. This ridge opposes the dislocation, but renders its reduction more difficult when once it has occurred.

Tuberosities of tibia

The inner and outer tuberosities of the tibia are partly epiphysial and partly diaphysial, but the epiphysial line runs below the facet for the fibula and the insertion of the semi-membranosus, and curves down in front, so that the tubercle of the tibia is usually formed as a tongue-like prolongation of the epiphysis.

Tubercle

The patella

The patella, though anatomically a mere sesamoid bone in the quadriceps extensor tendon, is surgically one of the most interesting bones in the body, liable as it is to various fractures by direct violence or muscular action, subject to dislocation, both acquired and congenital, occasionally deficient

altogether, as in some cases of genu recurvatum, in other cases much enlarged, especially as a result of syphilis, while its single centre of ossification is sometimes found inflamed, with resulting necrosis of the bone and perforation into the knee joint.

Joseph Collier has pointed out an important matter in connection with operations upon the knee joint, *i.e.*, the importance of preventing adhesion of the patella to the femur; if this occurs the action of the flexors is unbalanced by reason of the loss of the extensor insertion into the tibia in so far as its patellar attachment goes; hence flexion and sub-luxation are much more likely to follow if the patella is fixed than if it is kept mobile.

Knee joint

The synovial membrane of the knee joint covers the front of the femur to a distance of between one and two inches above the upper border of the patella, reaching somewhat higher on the inner than on the outer side. The cavity of the joint does not in its lower part overlap the edge of the tibia. So much of the tibial epiphysis is extra-articular that disease of the epiphysial line seldom extends to the joint.

Bursæ

Various bursæ are found in the vicinity of the knee joint, and may be subject to acute or chronic inflammatory changes calling for surgical treatment. The most important is the prepatellar bursa, which covers the lower part of the knee cap and the upper part of the ligamentum patellæ, and forms, when chronically enlarged, the swelling known as "housemaid's knee."

"housemaid's" knee

The other bursæ are relatively important or

unimportant surgically, as they communicate or not with the joint, and are or are not prone to inflammation.

Bursa beneath quadriceps

A bursa between the quadriceps extensor and the femur extends for about an inch above the superior *cul-de-sac* of the joint, and communicates with it in the majority of cases. Hence a wound, even three inches above the patella, may, through the medium of this bursa, open the knee joint.

Bursa beneath inner head of gastrocnemius

The bursa between the internal condyle and the inner head of the gastrocnemius and the semi-membranosus generally communicates with the joint, and is very prone to enlargement.

Bursa beneath popliteus

The diverticulum from the knee joint between the popliteus tendon and the outer tuberosity of the tibia may open into the tibio-fibular articulation, thus causing communication between the two joints.

Bursæ beneath semimembranosus

Between popliteus and ext. lat. ligt.

The bursa between the semi-membranosus tendon and the inner tuberosity of the tibia does not open into the joint, nor, as a rule, do those between the popliteus tendon and the external ligament and between the external condyle and the outer head of the gastrocnemius.

Beneath outer head of grastrocnemius

Beneath ligamentum patellæ

The enlargement of the bursa between the ligamentum patellæ and the tubercle of the tibia is especially painful owing to the compression of the sac in flexion of the knee. Enlargement of the bursa between the biceps tendon and the external lateral ligament may also cause pain owing to the proximity of the peroneal nerve.

Between biceps tendon and external lateral light

Loose bodies in joint

"Loose bodies" are more frequently found in the knee than in any other joint. This is perhaps chiefly owing to the large extent of the synovial fringes from which such bodies are developed and to the presence of the semi-lunar cartilages, which, when detached, furnish another variety. Hernial protrusions of the synovial membrane through the capsule are of some frequency in connection with the knee joint. These may subsequently become shut off from the joint and form cysts among the surrounding muscles (Baker's cysts).

Baker's cysts

Popliteal space

The popliteal space is bounded above and externally by the biceps, above and internally by the semi-tendinosus and semi-membranosus, and below on each side by the heads of the gastrocnemius. The semi-membranosus lies deeper than the semi-tendinosus, and the lower part of its belly reaches nearer to the middle of the space. The gracilis tendon is internal to that of the semi-tendinosus. The floor of the space is formed by the lower end of the femur, the posterior ligament of the knee joint, and the fascia covering the popliteus muscle. A mass of fat fills up the space around the various structures.

Popliteal artery

The popliteal artery enters the space at its upper and inner part, issuing from beneath the semi-membranosus, whose outer border forms the guide to the vessel. The artery passes downwards and outwards, so that it is in the middle line at the

lower part of the space. It bifurcates two inches below the upper end of the tibia into anterior and posterior tibial arteries.

and vein

The vein is at first outside the artery, but crosses it superficially at the middle of the space, and lies internal to it at the lower part.

Internal popliteal nerve

The internal popliteal nerve enters the upper part of the space in the middle line, external both to the artery and vein, but crosses the vessels superficially at the middle of the space, and lies internal both to the artery and vein at the lower end.

External popliteal nerve

The external popliteal nerve is given off at a varying level, and passes down to the neck of the fibula along the posterior edge of the biceps tendon. About half an inch intervenes between them, but care must be taken when dividing the tendon for contracture or other reason.

Articular branch of obturator

The branch from the obturator nerve to the knee joint lies upon the superficial aspect of the popliteal artery in the upper half of the vessel's course.

Popliteal artery

The popliteal artery is sometimes ligatured, and the operation can be done through a posterior incision with the edge of the semi-membranosus as a guide, or, better, through a lateral one just behind the tendon of the adductor magnus. The adductor is drawn forwards, the sartorius and semi-membranosus backwards, and the vessel found as it lies on the femur.

Collateral circulation

The collateral circulation is provided for by the following anastomoses:—

1. Anastomotica magna and descending branch of the external circumflex with the anterior and posterior recurrent and the superior fibular branches of anterior tibial.

2. Anastomotica magna with the superior internal articular artery.

3. External circumflex with the superior external articular branch.

4. Superior with inferior articular arteries.

5. Termination of profunda femoris, with muscular and upper articular branches of the popliteal.

Exploration of knee joint

The knee joint is most conveniently aspirated or examined through an incision on either side of the patella.

Popliteal surface of femur

The triangular surface at the back of the femur forming part of the floor of the popliteal space, is singularly prone to inflammation of a most tedious form, probably in consequence of its somewhat scanty blood supply; subsidence rarely occurs, and no sequestrum or distinct line of demarcation is formed, hence long continued suppuration usually follows, and amputation is very often ultimately called for.

Epiphyses

The lower epiphysis of the femur joins the shaft about the 20th year, and the upper epiphysis of the tibia joins its shaft about the 22nd year. Since most of the operations on joints are done in young people, it is important to remember that the growth in length of the femur after the second year takes

place almost entirely at the lower epiphysial junction. Hence, unless the extent of the disease demand it, the femur is never divided above the epiphysis in excision of the knee. In the ordinary operation of osteotomy the bone is divided well above this line, and growth is not arrested.

Head of fibula

The head of the fibula is prominent at the posterior part of the outer aspect of the leg just below the knee joint, on a level with the anterior tubercle of the tibia. The external popliteal nerve winds round the outer surface of the neck of the bone, and is here liable to strain and contusion.

Tibia

The anterior border and internal surface of the tibia are subcutaneous and often the seat of traumatic nodes.

Nerve distribution

The fascia of the leg receives part of the insertion of the sartorius, the gracilis, and the semitendinosus, and this fact is used by Mr. Hilton to illustrate his law of associated nerve distribution to muscle, skin, and joint, *i.e.*, there are distributed over the skin covering this fascia branches derived from the anterior crural or extensor, the obturator or adductor and the sciatic or flexor nerves.

Bursa

The bursa which intervenes between the expanded insertion of the sartorius and the underlying tendons of the gracilis and semitendinosus may be enlarged and form a swelling over the upper part of the internal surface of the tibia.

Anterior tibial artery

The line of the anterior tibial artery is from a point midway between the outer tuberosity of the

tibia and the head of the fibula to the middle of the front of the ankle. The artery lies on the interosseous membrane between the tibialis anticus internally and the extensor communis digitorum externally in the upper two-thirds of the leg, and afterwards between the tibialis anticus and extensor proprius pollicis, which last muscle crosses over the vessel from without inwards at its lower end. The interval between the muscles in which the vessel lies is in the line of the artery rather more than an inch from the ridge of the tibia. The anterior tibial nerve is external to the artery in the upper third of the leg, lies in front of it in the middle third, and is again outside it in the lower third. The venæ comites are closely applied to the artery and are usually included in the ligature when the vessel is tied. Blood finds its way into the dorsalis pedis through the anastomoses between the malleolar branches of the anterior tibial and branches of the posterior tibial arteries, and through those of the dorsalis pedis with the plantar arteries, the anterior and posterior peroneal and the calcaneal branch of the posterior tibial.

It is to be remembered that in tying the artery low down the upper part of the annular ligament will be notched and the sheath of the tibialis anticus opened.

The calf

On the back of the leg, the inner belly of the gastrocnemius is the more prominent and extends lower down. Between the inner belly and the tibia

is a groove in which the incision for ligature of the posterior tibial artery in the upper or middle sections of the leg should be made, at a distance of a finger's breadth from the inner border of the bone.

Posterior tibial artery.

The posterior tibial artery extends from the lower border of the popliteus opposite the tubercle of the tibia, to the inner side of the ankle, midway between the internal malleolus and the inner tuberosity of the os calcis. The vessel lies upon the tibialis posticus, flexor longus digitorum, tibia and ankle joint. At its termination it is beneath the internal annular ligament. The vessel is covered by the gastrocnemius and soleus. Two venæ comites adhere to the artery. The posterior tibial nerve is internal to the vessel for about the upper inch of its course but then crosses it superficially and lies on its outer side. The artery is covered by the layer of fascia which separates the deep muscles from the soleus and gastrocnemius.

In tying the vessel through the incision already mentioned, it should be remembered that the long saphenous vein passes up the leg just posterior to the site of the wound. The belly of the gastrocnemius is pushed backwards and the tibial origin of the soleus divided when the artery is found between that muscle and the tibialis posticus. There is some risk of the operator groping beneath the tibialis muscle if he does not keep a good finger's breadth posterior to the tibia.

Collateral circulation

After ligature of the posterior tibial the anastomoses mentioned in connection with the anterior tibial keep up the circulation. The following collateral channels are also of importance:—

1. Communicating branch between the posterior tibial and peroneal.

2. External calcaneal branch of peroneal anastomosing, with the external plantar artery.

The plantaris

The plantaris tendon, which is not infrequently ruptured in sudden tip-toe movements, or in an injury which is known as one form of "tennis leg," runs down from the outer condyle of the femur between the gastrocnemius and soleus to the inner side of the ankle, where it has a separate insertion into the posterior surface of the os calcis. Large veins accompany the muscle and are usually more or less torn at the time of the accident. Hence a considerable extravasation of blood follows, and while nothing but a fulness in the calf can be made out at the time, extensive discolouration appears in a day or two from the blood reaching the surface at the lower and inner part of the calf.

Peronea artery

The peroneal artery runs along the inner border of the fibula in a fibrous canal formed by the origins of the flexor longus hallucis and tibialis posticus. It is never ligatured deliberately, but requires to be tied in amputation of the leg, and is of importance as a collateral channel after ligature of the posterior tibial.

Internal saphenous vein

The internal saphenous vein lying behind the internal condyle of the femur may be traced downwards along the inner side of the leg, a short distance from the inner border of the tibia, to the front of the inner malleolus and along the inner border of the foot. Its chief surgical importance is its liability, in its main trunk or in its tributaries, to varicosity with its resulting evils. The vein has communications with the deep veins in the region of the ankle, and hence, as shown by Hilton, a level just above the ankle represents the lowest point in the blood column, and hence this is the part most prone to suffer from the ill effects of stagnant venous congestion.

Bones of the leg

With regard to the bones of the leg, it may be noted that the tibia is weakest at the junction of its middle and lower thirds, and the fibula at the junction of its middle and upper thirds. Oblique fractures of the tibia usually pass from below upwards and backwards, thus the anterior border leaves a sharp point at the seat of the fracture, which may give trouble by pressing against the skin. The sharp subcutaneous edge of the tibia is usually bevelled off in amputations through the leg at any level. It should be remembered that the tibia and fibula are of equal length.

Bony points of ankle

The bony points about the ankle and foot are of the greatest importance, not only in various operations on the part, but in localising disease and injuries.

The tip of the external malleolus is rather below and posterior to the level of the internal one. Rather more than an inch in front of the inner malleolus is the tubercle of the scaphoid, and about one inch below the malleolus is the sustentaculum tali of the os calcis.

Flat foot

The inferior calcaneo-scaphoid ligament stretches between the sustentaculum and scaphoid, and supports the head of the astragalus, which with the scaphoid forms a prominent projection inwards and downwards when the ligaments and muscles yield in "flat foot."

First metatarsal

The base of the first metatarsal bone can be felt most readily upon the dorsum, about $1\frac{1}{2}$ inches in front of the scaphoid tubercle. The prominent head of the metatarsal bone with the underlying sesamoids forms the ball of the great toe, so often distorted by ill-shaped boots and painful in flat foot and gout.

Peroneal tubercle

On the outer side of the os calcis, below the external malleolus is the peroneal tubercle which separates the peroneus longus tendon below from the brevis above, and is of some importance as a landmark in operations for talipes. Further forward is the sharp backward projection of the base of the fifth metatarsal bone, and midway between it and the tip of the malleolus is the line of the

Media tarsal joint

calcaneo-cuboid joint; the outer segment of the great transverse tarsal joint at which Chopart's

amputation is done; a joint of much importance also in tarsectomy.

Os calcis

The tuberosities of the os calcis cannot be very sharply defined owing to the thickness and toughness of the skin and subcutaneous tissue of the heel, but the inner tubercle can be moderately well made out and its position is important, since the incision in Syme's amputation must not cross the heel in front of these prominences, otherwise the flap can scarcely be dissected back.

The upper segment of the anterior annular ligament, stretching from the tibia to the fibula over the muscles and vessels, has beneath it only one synovial sheath, that for the tibialis anticus. The lower division of the ligament has three separate sheaths; one for the tibialis anticus, one for the extensor proprius hallucis, and one for the extensor communis digitorum and peroneus tertius. Tuberculous disease may spread along these sheaths from the tarsus.

Tibialis anticus

The tibialis anticus tendon is usually divided about one inch above its insertion. This point is below the termination of the synovial sheath.

Extensor hallucis

The extensor proprius hallucis tendon is external to that of the tibialis anticus, and its synovial sheath extends from the ankle joint to the base of the metatarsal bone. There is a bursa on the instep over or beneath the tendon.

The bursa surrounding the tendons of the extensor

communis digitorum may communicate with the astragalo-scaphoid joint (Holden).

Internal annular ligament

The internal annular ligament, stretching from the inner malleolus to the inner tuberosity of the os calcis, has four canals beneath it arranged as follows:—

Tibialis posticus

The tibialis posticus, after crossing beneath the flexor longus digitorum in the lower third of the leg has a separate synovial sheath which extends from one inch above the malleolus to the insertion of the tendon into the scaphoid. The tibialis posticus, together with the flexors of the toes and the front part of the internal lateral ligament, are divided in the operation of syndesmotomy, opposite the medio-tarsal joint.

Flexor longus digitorum

The flexor longus digitorum may be divided at the same point as the last muscle. It enters the compartment of the ligament next external to that of the tibialis posticus. Its synovial sheath extends from one inch above the malleolus into the sole of the foot, where the divisions of the tendon have separate thecæ.

The above tendons may also be divided by incisions above the annular ligament.

Posterior tibial vessels

The third compartment of the ligament is occupied by the posterior tibial vessels and nerve, the latter being external to the former. The pulse of the artery is readily felt midway between the inner tuberosity of the os calcis and the inner

malleolus, though much nearer the malleolus than the apparent prominence of the heel, since the thick skin of the plantar surface increases the projection of the os calcis. The vessel is easily ligatured through an incision carried round the inner malleolus and through the annular ligament.

Flexor longus hallucis

In the outermost compartment of the ligament external to the nerve, is the flexor longus hallucis tendon, which has a separate synovial sheath. Any of these sheaths may be the subject of inflammation and no doubt are so in most sprains of the ankle. They are also not rarely attacked by tubercle in tuberculosis of the ankle joint. The flexor longus hallucis tendon grooves the posterior aspect of the astragalus, and it should be borne in mind that the lip of this groove is sometimes torn off in severe sprains constituting a "sprain fracture." Care should be taken not to injure the tendon in excision of the astragalus.

External annular ligament

The external annular ligament stretches from the external malleolus to the outer aspect of the os calcis. It has beneath it the long and short peroneal tendons, the latter being nearest the fibula and placed higher than the former on the surface of the os calcis. The tendons are separated by the peroneal tubercle. Behind the fibula both tendons are enclosed in one synovial sheath which reaches $1\frac{1}{2}$ inches above the external malleolus, and divides into two processes which surround the tendons separately over the calcaneum. In the further part

Peroneal sheaths

of its course round the cuboid, the peroneus longus has a separate sheath.

The sheath of the peronei is sometimes the seat of a "ganglion," and the peroneus longus tendon is liable to dislocation, slipping forwards over the external malleolus.

Tendo Achillis

The tendo Achillis is so prominent that in a normal foot there could be no risk of injury to any other important structure in dividing it subcutaneously, but in severe talipes equino-varus, the heel and inner malleolus are so approximated and the vessels so displaced, that it is possible, though not very likely, that the posterior tibial artery might be wounded. The spot usually chosen for division is about one inch above the insertion of the tendon. A bursa lies between the insertion of the tendo Achillis and the back of the os calcis, and is not rarely the seat of inflammation.

A swelling, limited to the back of the ankle, filling the hollow at each side of the tendo Achillis, with none elsewhere, would probably be due to effusion into the bursa between the tendon and the os calcis, while an elongated swelling, running round between the inner malleolus and tendo Achillis, would probably be due to an affection of the tendon sheaths. On the outer side a similar swelling, without evidence of disease of the os calcis, should suggest effusion into the peroneal bursa.

Ankle joint

The level of the ankle joint is about half an inch above the tip of the internal and about one inch

above that of the external malleolus. The anterior ligament is thin and lax, the lateral ones much stronger; the posterior hardly exists, its place being taken by the posterior tibio-fibular ligament. Effusion into the joint first causes bulging in front beneath the extensor tendons, and afterwards fills up the hollows on each side of the tendo Achillis and around the malleoli. Swelling at the back must be diagnosed from that due to enlargement of the bursa between the tendo Achillis and os calcis.

Inferior tibio-fibular joint

The synovial membrane of the ankle joint also lines the inferior tibio-fibular articulation.

Dislocations

The dislocations of the ankle may be either backward, forward, lateral, or upward. They are all associated with rupture of various ligaments, and in many cases with fracture of the malleoli. Luxation of the foot outwards and backwards, with fracture of the fibula just above the malleolus, and rupture of the internal lateral ligament, or fracture of the tip of the internal malleolus, constitutes "Pott's fracture." A similar fracture of the fibula, with rupture of the inferior tibio fibular ligaments, or tearing away of the part of the tibia to which they are attached, and displacement of the astragalus upwards, constitutes "Dupuytren's fracture." In upward dislocation the inferior tibio-fibular ligaments are torn, the two bones separated, and the astragalus forced between them.

Fractures

Dorsal artery

The dorsal artery of the foot lies between the extensor proprius hallucis tendon and the inner-

most slip of the extensor longus digitorum. The anterior tibial nerve lies external to it. The vessel rests on the astragalus, scaphoid, and middle cuneiform bones, and is crossed superficially near its termination by the innermost slip of the extensor brevis digitorum. It passes down between the heads of the first dorsal interosseous muscle to anastomose with the termination of the external plantar. The line of the artery is from the centre of the front of the ankle joint to the interval between the two inner toes.

Extensor brevis

Beneath, or slightly external to the extensor longus digitorum tendon the head of the astragalus is prominent on the dorsum when the toes are pointed. Below and external to this the belly of the extensor brevis digitorum is easily made out when the toes are dorsiflexed. This muscle is supplied by the anterior tibial nerve and hence wastes with the anterior muscles of the leg.

Tarsal sacs

The arrangement of the tarsal synovial sacs is of considerable surgical importance first, in localising the exact site and extent of disease, and secondly, from a prognostic point of view, in determining how far disease is likely to spread and what extent of operation may be required for its removal. Distension of the ankle joint itself causes a flattening of the front of the ankle from filling up of the hollows and consequent diminution of the salience of the extensor tendons. When the ankle joint is swollen the toes are "pointed." Effusion

into the posterior calcaneo astragaloid joint lying behind the interosseous ligament causes some fulness below the malleoli on each side, but this does not extend as far back as swelling in disease of the ankle joint, and does not show at all in front.

Where the anterior calcaneo astragaloid joint is distended, its prolongation, the astragalo scaphoid articulation, must also be effected. Hence there is swelling below and in front of the inner malleolus as far forward as the tuberosity of the scaphoid, and also over the head of the astragalus on the dorsum of the foot.

Distension of the calcaneo-cuboid joint is easily localised, but is rarely great in amount, owing to the resistance of its strong ligaments. Similarly effusion into the joint between the internal cuneiform and first metatarsal, and into that between the cuboid and two outer metatarsals is readily localised.

All the other tarsal and tarso-metatarsal joints are lined by the common tarsal sac, and when this is involved, an extensive swelling appears, giving the foot a bulbous appearance in front, while the ankle joints and other articulations mentioned remain free from swelling; but it often happens that disease spreads from bone to bone, and more than one articulation is affected. In many cases, however, the exact condition of matters can be made out.

Bursæ are often found enlarged over the meta- **Bursæ, &c.**

tarso phalangeal joint of the great toe, and over the base of the fifth metatarsal bone.

Medio-tarsal joint

The medio-tarsal joint, at which Chopart's amputation is carried out, runs transversely across the tarsus from the calcaneo cuboid joint to just behind the scaphoid tubercle.

Tarso-metatarsal joint

The tarso-metatarsal joint, at which Lisfranc's operation is performed, runs obliquely between the bases of the first and fifth metatarsal bones. It should be remembered that the general line of the joint is broken by the backward projection of the second metatarsal bone. Amputations at these sites are rarely done now in the living subject.

Skin of sole

The skin of the sole is extremely dense and tough, and well suited for bearing pressure, hence all amputations about the ankle and foot are so designed that the stump shall be covered wholly or mainly by a plantar flap.

Plantar fascia

The plantar fascia is similar in arrangement to, but stronger than the palmar, and has a corresponding effect in confining collections of pus etc. It stretches from the tubercles of the os calcis to the heads of the metatarsal bones. The median portion covers the flexor brevis digitorum and the lateral portions the abductors of the great and little toes. As in the palm, vertical septa pass down into the sole along the lines between the middle and lateral portions of the fascia. The fascia assists in maintaining the longitudinal arch of the foot, and is found contracted in cases of talipes equino-varus.

Posterior tibial artery

The posterior tibial artery bifurcates at the lower border of the internal annular ligament. Hence, in the incision for amputation of the foot by Pirogoff's method, the plantar arteries would be divided, while in Syme's operation the incision being a little farther back would sever the posterior tibial itself.

Plantar arteries

The plantar arteries are of little surgical importance. The smaller inner artery is often divided in operations for club foot, as it passes forwards to the first interosseous space beneath the abductor hallucis. The larger external artery passes forwards and outwards towards the base of the 5th metatarsal bone lying between the flexor brevis and flexor accessorius muscles. It escapes wound in "syndesmotomy," since it lies behind the crease of the sole in which incisions are made. After reaching the base of the fifth metatarsal the artery turns inwards across the metatarsal bones between the adductor hallucis and the interossei, forming the plantar arch. It can be reached in this part of its course by removing a portion of one of the metatarsal bones through a dorsal incision.

Plantar nerves

The internal plantar nerve supplies the plantar aspect of the $3\frac{1}{2}$ inner digits and a corresponding portion of the sole of the foot to that supplied by the median in the palm. The external plantar supplies the outer $1\frac{1}{2}$ digits on their plantar aspect, and the outer part of the sole.

The skin of the heel and contiguous portion of

the inner border of the foot is supplied by the internal calcaneal twig from the posterior tibial. These nerves are sometimes of importance, since much pain may be caused by their being involved in fibrous thickening from injuries, etc. The nerves about the heel, sole and balls of the toes are often painful in gonorrhœal rheumatism. The digital nerves, especially those to the second and fourth toes, are sometimes so troublesome that pain due to pressure on them by the head of the metatarsal bone has received the distinctive name of "metatarsalgia" from the American surgeon Morton, who described the affection. The ankle joint is supplied by both anterior and posterior tibial nerves, and is thus associated with the nerve supply of the knee.

"Metatarsalgia"

Nerves of dorsum of foot

On the dorsum, the contiguous sides of the hallux and second toe are supplied by the termination of the anterior tibial nerve, the outer side of the little toe by the external saphenous, and the rest by the musculo-cutaneous, whose branch to the inner side of the great toe communicates with the internal saphenous nerve. The dorsum of the foot is supplied by the musculo-cutaneous and long and short saphenous nerves. Mr. Hilton points out that there is no dorsal branch of the plantar digital nerves comparable to that of the palmar.

Arches of the foot

The anatomy of the arches of the foot requires a brief notice here, since distortion of these arches is so commonly seen in "flat" and "splay" foot.

The antero-posterior arch is best developed on the

inner side. Its piers are formed by the os calcis behind and the heads of the metatarsal bones in front. The arch may be looked upon as made up of two parts in front with a common support behind. The inner division consists of the os calcis, the scaphoid, the cuneiform bones, and the three inner metatarsals, the outer of the os calcis, the cuboid, and the fourth and fifth metatarsal bones. The astragalus is the keystone at the summit of the arch. Any structure which stretches in a straight line beneath the concavity of the arch and resists the separation of the anterior and posterior piers is said to act as a "tie." Such are the plantar fascia, long and short plantar ligaments, abductor hallucis, tendons of the flexor hallucis and flexor longus digitorum, the flexor brevis digitorum and flexor accessorius which acts by tightening the tendons of the flexor longus. The tibialis posticus slings up the head of the astragalus as it passes from the sustentaculum tali to the scaphoid, and materially supports the action of the inferior calcaneo-scaphoid ligament. The tibialis anticus, by its traction upwards and backwards, acts as a tie from above on the anterior pillar of the arch. Each component of the arch is fastened to its neighbours by short ligaments, and separation cannot occur without yielding of these. Of the latter the inferior calcaneo scaphoid and the anterior part of the internal lateral ligament of the ankle joint are important members.

The transverse arch of the foot is best seen in the line of the tarso-metatarsal joints, and is found to be fundamentally due to the wedge shape of the cuneiform bones and the heads of the metatarsals, whose plantar surfaces are narrow while the dorsal are broad. The general transverse concavity is maintained by the short ligaments binding closely the plantar aspects of the bones. The chief "tie" of the transverse arch is the peroneus longus tendon, which, by its course across the sole from the cuboid to the base of the first metatarsal, greatly hinders the separation of the transverse pillars. The oblique and the transverse adductor muscles of the great toe also act, to some extent, in the same way. The "piers" of the arch are at the inner and outer borders of the tarsus, and its "crown" is to the inner side of the middle line of the foot. Collapse of the transverse arch causes "splay foot" of the antero-posterior, "flat foot."

For an account of the symptoms caused by flat and splay foot, references must be made to surgical works, but it may be here pointed out that the pain in these affections is due to strain upon ligaments, to pressure by the weight of the body upon parts unused to and unfitted for it, and to direct pressure by bones upon certain nerve filaments as well as to secondary inflammatory changes resulting from these abnormal conditions.

The toes

Making allowance for the difference in size and shape, the anatomy of the toes almost exactly cor-

responds to that of the fingers. The tendons of the flexors brevis and longus digitorum, are enclosed in digital synovial sheaths. The tendons of the flexor brevis digitorum bifurcate, and are inserted into the middle phalanges like the flexor sublimis tendons of the hand. The lateral ligaments of the inter-phalangeal joints lie on the flexor side of the long axis of the toes, and hence tend to maintain the flexion seen in hammer toe.

The flexor brevis hallucis sometimes interposes an obstacle to reduction of dislocation at the first metatarso-phalangeal joint similar to that observed in connection with the thumb. The joint itself is the site *par excellence* for attacks of acute gout and also for "perforating ulcer," whilst enlargement of the bursa sometimes found over it, together with distortion, chiefly abduction of the toe, constitutes a "bunion."

The metatarso-phalangeal joints of the toes are about one inch behind the free edge of the web.

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